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The Role of Mental Imagery in Creativity

**A thesis submitted to Middlesex University in partial fulfilment of
the requirements for the degree of Doctor of Philosophy**

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June 1999

Abstract

Mental imagery has been linked to creativity through the reports of many historically creative individuals. Following a review and evaluation of the theoretical, anecdotal and empirical literature, the material presented in the thesis investigates the role of individual differences in mental imagery in performance on psychometric creativity tasks. A meta-analytic review of previous research showed a small marginally acceptable criterion association between self-reported mental imagery vividness and control and divergent thinking performance. However, additional non-statistical examination showed that further investigation was required. This led to five studies of the variables under consideration and a revised meta-analytic review in the light of the findings. The main conclusion was that self-report measures of mental imagery have a statistically significant but inconsequential association with divergent thinking performance. Consequently a new series of studies was undertaken in which the creative visualization task (CVT) was employed using an individual differences approach. Having established the parametric properties of a test-format version of the CVT two behavioural measures of mental imagery were used to predict performance. As neither measure predicted CVT performance high and low vividness and Symbolic Equivalence Test groups were used to assess a dissociative model of CVT performance. A significant interaction effect showed that vividness plays a mediating role in predicting CVT performance. In two final studies the individual differences approach was employed in the context of a hypothesised perceptual mediation. The results showed firstly that High Imagers performed significantly better than Low Imagers in creativity tasks following perceptual isolation and secondly that Low Imagers performed significantly better on perceptually sourced creativity tasks than on verbally sourced creativity tasks. The combined findings suggest that, while established protocols do not support a strong imagery-creativity association, new methods of investigation may reveal the predicted differences in creativity between high and low imagery participants.

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In Memory of

Patrick Smythe
Micheal Smythe
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Chapter I

Mental Imagery and Creativity. Some Introductory Thoughts on the Uses of Mental Imagery by Historically Creative Individuals.

Introduction

The primary aim of the present chapter is to provide a clearer understanding of the relationship between mental imagery and creativity. Its inclusion is necessary in order to dispel many of the myths that have surrounded the role of mental imagery in creativity. The ideas dealt with include the notion that mental imagery is both a necessary and sufficient condition for creativity, and the view that there is a general mental imagery heuristic used in the creative process. Despite the fact that arguments in favour of these beliefs can easily be shown to be fallacious, through the use counter argument and anecdotal reports, they have been adopted by many researchers in the field (e.g. Finke, 1990; Rothenberg, 1979 Shepard, 1978ab) and have frequently been used as a *raison d'être* for investigating mental imagery *per se*.

The secondary aim is to provide a basis upon which mental imagery is to be understood in the context of creativity. Simply stated, this is that if the role of mental imagery in creativity is to be understood, the discussion must start from a realistic basis, namely, that the occurrence of a mental image does not automatically lead to creativity and that when mental images are implicated in the process, they appear in a variety of ways.

Creativity in the Absence of Mental Imagery

Mental imagery has been a controversial area in psychology for over 80 years. The effect of the Wurtzberg School's imageless thought debate and Watson's (1913) attack upon introspective psychology resulted in a neglect of the area for 50 years. When the subject did return to mainstream psychology it was quickly embroiled in the debate over whether representations could take on an analogical form (Pylyshyn, 1973, 1981). In the past decade mental images have again fallen out of favour with psychologists as neural networks, normally in the form of perceptual devices, have offered a stronger challenge to the symbolic representationalists. Again mental imagery research has been marginalised and those who work in the field may feel that its role is generally underestimated in psychology.

While those researchers may be justified in claiming that mental imagery has been devalued, they are also guilty of distortion. In their case, however, the problem concerns the exaggeration of mental images in psychology. Nowhere is this more evident than in

the study of creativity where there are numerous examples of overstating the usefulness of mental imagery. Finke (1990), for example, introduces his book on mental imagery and creativity by stating that:

"Every person has the potential to make creative discoveries in their imagery" (Finke, 1990, p.1).

Others have emphasised the role of specific types of mental imagery in science (Shepard, 1978ab), or in the arts (Rothenberg, 1979, 1995; Rothenberg and Sobel, 1980). Implicit in these claims is that mental imagery is essential to the creative process and that a failure to recognise mental images in cognition will lead to the omission of those achievements which are most cherished by our society. Creativity, it would seem, is reason enough to study mental imagery.

While mental images can facilitate problem solving tasks, specifically those which require the application of original strategies, they are neither a necessary nor a sufficient condition for the resolution of problems. For every historically creative individual who has made a claim to the use of mental imagery, it is likely that there are many more who have not. After all, if mental imagery is so essential to the creative process, then it is remarkable that it has been ignored, or passed over as a footnote, by so many writers on the subject area (e.g. Boden, 1990, 1994; Eysenck, 1994, 1995; McGuire, 1997; Ochse, 1990; Sternberg, 1988).

Some writers have even suggested that mental images do not facilitate the creative process at all. Weisberg (1993), who is sceptical about the involvement of any special purpose processes in creativity, in a study of the reports of a broad range of creative individuals (e.g. Coleridge, Mozart, Darwin, and Poincaré), claims that those factors associated with inspiration, especially visions, are embellishments of the creator. The claim to have visions gives the impression of a difference between creative individual and ordinary individuals.

Whilst acknowledging that creative individuals are likely to embroider their reports of the creative process, it is unlikely that the significance of all of these reports is inconsequential. However, it is the case that in certain circumstances mental images can prove to be a hindrance to the creative process. Boden (1990), for example, claims that mental images - or "analogical representations"- when used in the wrong conceptual frame can hinder the problem solving process. In demonstrating this Boden refers to two

examples. The first is a trick-puzzle that invokes mental imagery but can only be resolved with the use of a non-imagery heuristic (see Boden, 1990, p.103). The second example concerns the invention of Euclidean geometry proofs, specifically the proof that the base-angles of an isosceles triangle are equal, by a geometry program (using an algorithmic strategy). The program, which was unable to use a visual representation, produced a more elegant way of proving the isosceles theorem than Euclid who had access to a visual representation. The crux of Boden's argument is that in these examples, and many others, there is a temptation to use mental imagery in the problem solving process. However, the adoption of such a strategy is unlikely to lead to any creative insight. Thus, mental images, although useful in some circumstances, can prove to be an obstacle to creativity.

Poincaré (1908/1952), a mathematician, was also sceptical about the status attributed to mental images in the creative process. Despite his acknowledgement that the resolution of a class of Fuchsian functions emerged from a hypnagogic reverie, he was aware of the frequently deceiving nature of mental images. He suggests that the inspirational feelings associated with these states should not be taken too seriously as the claims inherent in them are frequently unwarranted. As he states:

"I have often spoken of the feeling of absolute certitude accompanying the inspiration; in the case cited this feeling was no deceiver, nor is it usually. But do not think that this is a rule without exception; often this feeling deceives without being any the less vivid, and we only find it out when we seek to put on foot the demonstration. I have especially noticed this fact in regard to ideas coming to me in the morning or evening in bed while in a semi-hypnagogic state." (Poincaré, 1908/1952, p.27).

Thus, although Poincaré often made use of the images occurring during these periods, he was well aware of the dangers of treating the ideas emerging from these mental images with the certainty that they had initially conveyed.

From these arguments it can be concluded that mental images are neither a necessary nor a sufficient condition for creativity. While it is the case that there have been many reports of the use of mental imagery in creativity, it must not be forgotten that in some cases there is no use for mental imagery. It is tempting to count only the positive instances but this will not lead to a better understanding of the role of mental imagery in

creativity. The implications of this for empirical research are considerable as there is unlikely to be a simple causal relationship between the two variables.

The Case Against a General Mental Imagery Heuristic

Mental imagery may not be a necessity for creativity, and in some cases it may be an impediment, but there are many reports of the use of mental imagery in original thinking. These accounts have been provided by a diverse range of individuals from both the sciences and the arts. This has led many to propose a specific role for mental imagery in creativity, a mental imagery heuristic. Two of the most well known imagery strategies advocated for the enhancement of original thinking are proposed by Finke (1989, 1990, 1996; Finke & Slayton, 1988) and Shepard (Shepard, 1978ab). Finke, proposes a creative visual synthesis hypothesis for the role of mental imagery in creativity. Here mental imagery is used as a tool in developing novel combinations of stimuli. Shepard (1984), claims that creativity occurs through the *voluntary* manipulation of mental images; analogous to his mental rotation paradigm (e.g. Shepard & Metzler, 1971). Similarly, Rothenberg (1979, 1995; Rothenberg and Sobel, 1980) claims that homospatial and Janusian thinking are central to the development of creative ideas. Others have emphasised vividness (Shaw & De Mers, 1986), control (A. Richardson, 1969; Campos & Perez, 1989), and cognitive style (Forisha, 1983) as crucial to the deployment of cognitive strategies. Alternatively, there are some who believe that it is the emergence of an unconscious flow of thought (primary process thinking) that enables mental imagery to be used as a successful tool for creativity (Suler, 1980).

In all of these notions of the relationship between mental imagery and creativity there is the underlying belief that the source of creativity resides in the use of a specific aspect of mental imagery. However, the testimonies given by historically creative individuals do not imply a single strategy for mental imagery in creativity. Rather (like the ideas put forward collectively by the mental imagery researchers), they demonstrate that there are a multitude of factors inherent in both mental imagery and the domain in which the process occurs.

The reasons why mental imagery should not be treated as a general heuristic in the creative process are numerous. Anecdotal reports of the use of mental imagery in the creative process differ in many respects. The most prominent factors are: the vividness of

the mental image; the amount of control exerted over the mental image; the context in which the mental image occurs; and the content of the mental image. All of these factors effect the adoption of a heuristic in the creative process.

There are also obvious differences in the creative process which suggest that a single strategy would not satisfy the range of circumstances in which creativity has taken place. At a macroscopic level Gruber (Gruber,1989; Gruber and Davies, 1988) may be correct in his assertion that there are common constituents in the process of creativity. However, there are also differences, some of which can be quite dramatic. For example an obvious difference can be found in the availability of information to the sciences and the arts.

Science, for example, involves the imposition of constraints not normally associated with the arts. The arts may be bound by a specific paradigm or they may break from that paradigm and create a new standard. Here there is no difference between the scientist and artist. However, in both the problem domain and the problem solution there may be divergence. For example, the scientist is more bound by the history of the subject than the artist. That is, they are subjected to a theory replacement (Kuhn, 1970) or at least to a reduction-replacement continuum (Churchland, 1989). While it is perfectly reasonable for an artist to take features from several schools and develop them into new art forms (e.g. Dali's use of renaissance perspective, Klimt's use of pre-renaissance art), a scientist is invariably compelled to discard everything that has been superseded by a later paradigm (Foss, 1995). Einstein, for example, could not insert Aristotelian notions of physics into his theory of relativity because the Newtonian model of physics had become untenable; or unfashionable in artistic terms. Thus, in terms of the applications of a strategy the artist has a wider selection of methods s/he can adopt.

Most importantly, people differ in their mental imagery abilities (Marks, 1973; Harshman and Paivio, 1987; Paivio, 1978a) and in the way they use mental imagery (Forisha, 1983; Paivio, 1971; A.Richardson, 1969, 1977). This difference has been found amongst groups in the general population. Harshman and Paivio (1987), for example. found sex differences in the way that mental images are constructed; episodic memory images for females and generic images for males. Isaac and Marks (1994) found evidence of developmental differences for males and females and also evidence of specialisation in different occupational groups. There are also an immense number of ways in which a

mental image can be defined and therefore a variety of options are available to the individual (see Chapter Three).

Altogether, these arguments demonstrate that it is unlikely that a general mental imagery heuristic is used to facilitate the creative process. The strongest evidence against a general heuristic, however, can be derived from the reports of historically creative people who asserted the use of mental imagery. The most remarkable feature of these reports is that they differ in both the types of mental imagery used and in the way in which the mental images are treated. For the purposes of creating *The Ancient Mariner* or *Kubla Khan* Coleridge's ingestion of opium proved to be a worthwhile way of enhancing the imaginal processes (Coleridge, 1816/1952). This, though, would hardly have suited Helmholtz's purposes (Ochse, 1990). He preferred to take solitary walks and allow his mind to wander around a problem. Freud viewed mental images in a completely different way to those before him (Fancher, 1979); this in itself could be said to constitute a creative insight. Freud believed that images held the key to the unconscious components of mind and set about recording and translating them. Einstein, was even more deliberate in his use of mental images. He produced them at will and used them to perform thought experiments (Miller, 1989, 1992; Shepard, 1978a). Kekulé had no conscious control over his mental images at all. He relied upon the ideas startling him into an alert state (Boden, 1990; Partington, 1964). Dali and Edison could not even rely on being woken by their mental images, and had to devise plans to do so (Mavromatis, 1987); Dali, rested his chin on a spoon and Edison held steel balls in his hands which would fall noisily onto a tray as he drifted from the hypnagogic to the sleep state.

In summary, an understanding of the relationship between mental imagery and creativity will require a great deal more than advocating a specific strategy. Those who adhere to the, "use mental imagery" philosophy fail to acknowledge the great variety of circumstances in which creativity occurs and the many ways in which mental imagery is augmented.

Two Cases of the use of Mental Imagery in Creativity

So far it has been argued that mental imagery is neither a sufficient nor a necessary condition for creativity. It has also been suggested that mental images can sometimes prove to be an obstacle to creativity and that there are no reasonable grounds

for assuming that there is a general mental imagery heuristic used in the creative process. The aim of the following accounts is to reinforce the latter point by contrasting the use of mental imagery in two scientists, i.e. Kekulé and Einstein.

There are several reasons why the reports from Einstein and Kekulé have been selected. The first is that they are frequently cited together as a kind of heuristic brethren (e.g. Kuzendorf; 1982; Shepard, 1978a) with little regard for the differences apparent in the use of mental imagery. The second reason is that the examples of creativity by Kekulé and Einstein are two of the most important achievements in science. Thirdly, they have been selected because, while there are many similarities in the conceptual structure of the problems, there are obvious contrasts in the use of mental imagery. Finally, they have been chosen because they represent the two most prevalent ways of using mental imagery in creative problem solving, namely, in a hypnagogic or a thought form.

Kekulé's Discovery of the Benzene Ring

The problem faced by Kekulé in developing a model of the compound benzene was that the known atomic constituents of benzene, six carbon atoms and six hydrogen atoms (C_6H_6), violated the then known principles of structure and valence in carbon compounds. To fully recognise the magnitude of Kekulé's resolution to the problem it is necessary to explain the position of chemistry when Kekulé was working. Initially, however, a brief review of his use of mental imagery will be undertaken.

Kekulé's Use of Mental Imagery

Kekulé was working in chemistry at a transitional stage in its development. Through laboratory work it had become possible to identify the various elements that make up a compound structure. However, the principles that governed the development of structure were not clearly understood. The main reason for this was that the key components in the valency process, electrons, were not identified until the end of the century. In this respect the position of chemistry in the second half of the nineteenth century was limited in its use of the purely inductive method (see the section on Einstein's use of mental imagery for further details on the then accepted modes of operation). In summary progress was dependent upon the then unorthodox *hypothetico-deductive* method of discovery.

If Kekulé had persisted with a purely inductive methodology for the derivation of chemical structure then he would not have been able to resolve the benzene structure problem. This is evident in both of his major discoveries, i.e. the valency of carbon compounds and the discovery of benzene ring structure. The means by which he formed hypotheses concerning both of these findings was through the use of mental imagery. In each case Kekulé is alleged to have had an unfolding reverie in which the solution appeared to him. In the first case, the discovery of the valency of carbon, the image offered a direct solution to the problem. In the second case, the discovery of the benzene structure, the image required a translation to its chemical form.

Kekulé's use of mental imagery can be summarised as a tool through which hypotheses were formed. The images formed occurred during circumstances that were not directly related to finding the solution to the problem. They were passively received by Kekulé in an almost prophetic style. In other words the only conscious role played by Kekulé was in recognising them as the solution to the problem he had been searching for.

The Problem Domain: The Contradiction Between the Structure and Valence of the Carbon Compound Benzene

The knowledge of both the structure and the valency (the potential of an element to bond with other elements) of compounds in 1865 was limited. It wasn't until the beginning of the twentieth century, following the discovery of the electron by Thomson in 1897, that the structure of atoms was sufficiently understood to enable a proper evaluation of the role of valency in compound formation. However, chemists were able to identify elements in compounds and from this deduce a linkage theory.

By the mid 1850s a reasonable body of knowledge concerning valency had been accrued. Using hydrogen as a measurement of valency potential it had been possible to deduce the valences of many elements. In 1854 Kekulé proposed that combinations of elements occurred as a consequence of the valency potentials of the atoms in the compounds, as opposed to chance interaction. For example, the constituents of water, two hydrogen atoms and one oxygen atom (H_2O), develop because hydrogen (valency = 1) has a valency half that of oxygen (valency = 2). Thus, a compound of three hydrogen atoms to one oxygen atom (H_3O) could not occur unless oxygen had a valency three times greater

than the valency of hydrogen. Kekulé referred to this relationship within compounds as “affinity”.

Kekulé's main concern was in understanding the structure of carbon compounds. It had been acknowledged by this time that carbon must have special properties that make it so prevalent in organic compounds. In 1857 Kekulé established the first property of carbon, namely, that it had an invariant valency of four units. Thus, in a simple carbon compound containing a single carbon atom, four hydrogen atoms, or two oxygen atoms, would be required for an affinity to be reached. However, in more complex compounds carbon did not appear to follow the four valency unit rule.

In 1858, Kekulé published his structure theory of chemical compounds. The structure theory proposed that constituents of a compound were arranged in a specific relation to each other. The larger atoms (Kekulé symbolised atomic size according to valency potential, e.g. see Figure 1.1) attached themselves to the smaller atoms in arrangements of affinities. A further feature of the structure theory pertained specifically to carbon atoms. Kekulé claimed that a second special property of carbon was its ability to form a union between itself and other carbon atoms and that this bond remains even when other elements are replaced in the compound; the discovery of carbon bonding was found independently in the same year by Couper. This explained both the reduction in valency in complex carbon compounds and the proliferation of carbon in organic compounds, which were often formed of large molecular arrangements.

The dual concepts of chain structure and carbon to carbon bonding were derived from a mental image. Although the ideas were not expounded until 1858, Kekulé claimed that the original notions appeared to him in 1854 whilst daydreaming on a London omnibus. This account was given several years later:

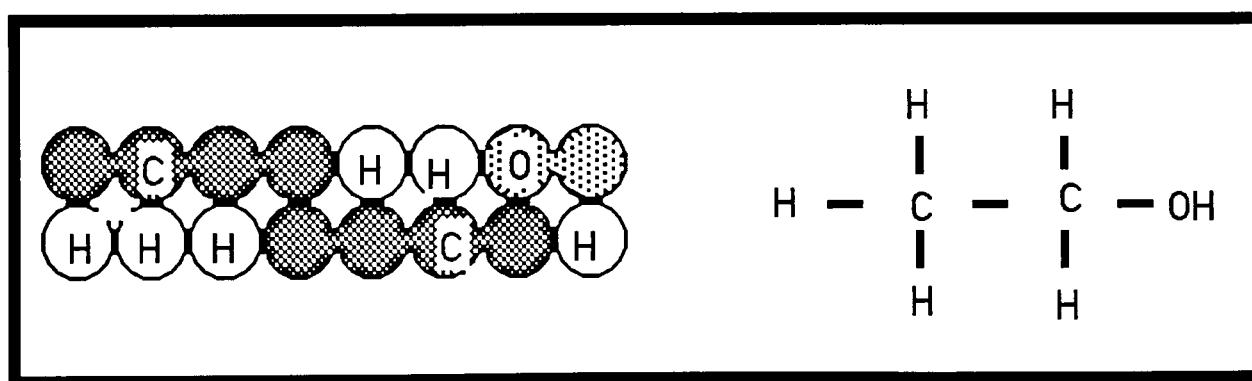
"I fell into a reverie. The atoms were gambolling before my eyes. I had always seen them in motion, those small beings, but I had never succeeded in discerning the nature of their motion. Now, however, I saw how, frequently, two smaller atoms united to form a pair; how a larger one embraced the smaller ones; how a still larger one kept hold of three or even four of the smaller; whilst the whole kept whirling in a giddy dance. I saw how the larger ones formed a chain and the small ones hung

on only at the end of the chain." (Kekulé, cited in Partington, 1964, p.537).

Clearly, the theory of structure and carbon linking in chains was given to Kekulé complete in his reverie. This linkage also explains the valency values required by the sum of the elements. The addition of carbon atoms results in an alteration of valency for the compound. For example, in a compound containing two carbon atoms six valency units would be required to reach an affinity because the carbon atoms share a valency unit (i.e. $C_2 = 6$). With three carbon atoms a minimum of eight valency units would be required to reach an affinity (i.e. $C_3 = 8$). With four carbon atoms a valency of ten would be required ($C_4 = 10$).

In summary organic chemistry, that is, the study of carbon compounds, was governed by two principles underlying the structure of all organic compounds. The first was that carbon atoms catenate thereby producing string compounds. The second principle was that atoms have valency units and that these valency units determine the combination of organic compounds. These principle had worked efficiently for Kekulé and others in defining the structure of several organic compounds. For example, the number of non-carbon atoms in ethyl alcohol was sufficient to fulfil the chain/valency principle proposed by previous research.

Figure 1.1 The Structure of Ethyl Alcohol



Kekulé's structure theory was successfully applied to alcohol compounds. for example, the structure of ethyl alcohol confirmed the prevailing notion that carbon atoms were quadrivalent and formed string combinations with other chemicals. However, the contradiction between valency and structure emerged when the same applications were attempted with carbocyclic compounds.

When Kekulé attempted to describe the structure of the compound benzene he was confronted with a contradiction. The atomic constituents of benzene did not conform to the principles of structure and valency. In other words benzene consisted of six carbon atoms and six hydrogen atoms, yet the minimum number of hydrogen atoms required to reach an affinity should be fourteen (i.e. $C_6 = 14$). This problem was also encountered with other compounds, which, having a distinct odour were collectively referred to as the 'aromatic compounds'. Kekulé's early attempt to resolve the contradictions inherent in the structure of the aromatic compounds was to suggest that the density of carbon atoms was relative to the compounds they were in (1858, cited in Partington, 1964). This meant that in simple compounds, e.g. alcohol, carbon was quadrivalent, but in larger compounds the valency was altered. However, this view contradicted the assumption that carbon had an invariant valency potential, a notion that Kekulé was clearly attached to.

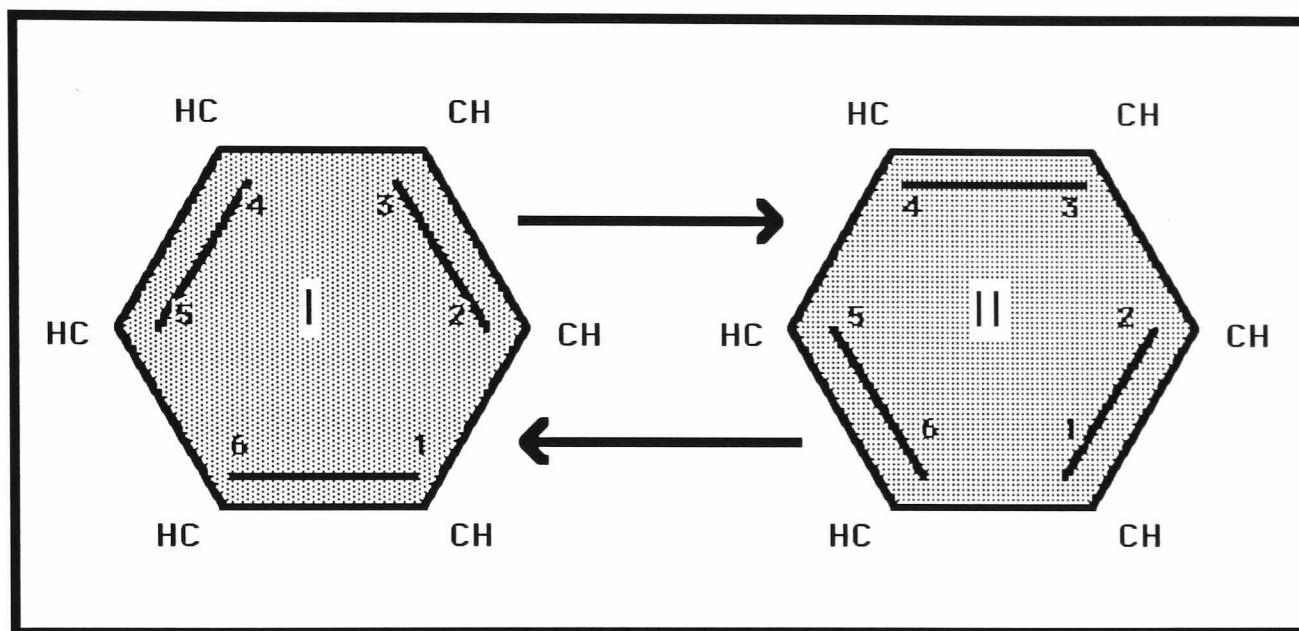
The resolution of the benzene compound problem was achieved by Kekulé in 1865. There are two features of the benzene ring that distinguish it from the previous beliefs held about compound formation. The first is in the structure, instead of having chains of atoms Kekulé proposed a ring structure in which the six carbon atoms linked to each other. The origin of this idea came from a complex set of kinematic hypnagogic images which came to Kekulé after unsuccessfully deciphering the problem. As Kekulé states:

"I turned my chair to the fire and dozed. Again the atoms were gambolling before my eyes. This time the smaller groups kept modestly in the background. My mental eye, rendered more acute by repeated visions of this kind, could now distinguish larger structures, of manifold conformation; long rows, sometimes more closely fitted together; all twining and twisting in snakelike motion. But look! What was that? One of the snakes had seized hold of its own tail, and the form whirled mockingly before my eyes. As if by a flash of lightning I awoke."
(Kekulé, cited in Boden, 1990, p.16).

The dream differs from the previous image Kekulé had in that it includes both representational and symbolic imaginal forms. It commences as before with a random selection of atoms moving around in space, then, however, the larger atoms (carbon it is recalled was perceived to be a large atom, see Figure 1.2) take the foreground. This time,

however, they are not only forming chains but are moving in a flexible state of unison. From here the atoms turn into snakes, a symbolic state, and when one of the snakes bites its tail Kekulé is awoken only to turn them back to a representational state and partially resolve the benzene problem.

Figure 1.2 The Discovery of the Benzene Structure



Kekulé resolved the contradiction of valency and structure by modifying both principles. In modifying the structure principle he introduced the notion of stable ring forms in carbon chemistry. The valency of carbon remained at four units but the idea of a double valency was introduced.

From this image Kekulé developed a hexagon structure for benzene compounds whereby the six carbon atoms formed a ring (a common nucleus) and the remaining six hydrogen atoms linked to each carbon atom on the periphery of the compound (see Figure 1.2.). This, though, did not fully explain the structure/valency problem inherent in the benzene compound. Even with all of the carbon atoms linked together and the hydrogen atoms on the outside there remained an excess valency of 6 (i.e. $C_6 = 12$).

Kekulé's second invention was the concept of bivalency. He deduced that if the carbon atoms formed a ring structure and the hydrogen atoms bonded to the periphery of the structure then the excess valency (six units) must be consumed within the common nucleus of the compound. The only way to resolve this was to suggest that some of the carbon atoms had a bivalency, that is, they bind with two rather than one affinity unit; known now as a resonance structure. If this were the case than Kekulé realised that there would only need to be three bivalent atoms. The problem was which of the carbon atoms

should be bivalent? Which should not be bivalent? And according to what criteria should bivalency be designated? The answer to the problem was to delocalise the bivalency from the element and place it within the common nucleus of the compound. Benzene, it was concluded, has a two-phase structure where each phase satisfies the affinity level (i.e. $C_6 = 6$) for the six carbon atoms. In phase one, the bivalent links are between carbon atoms 1-2, 3-4, and 5-6, the remaining links are univalent. In the second phase the bivalent links are between carbon atoms 2-3, 4-5, and 6-1. This perpetual motion of bivalency (see Figure 1.2) produces the necessary valency potential during any one period in the existence of the compound.

Einstein's Special Theory of Relativity

The problem faced by Einstein has many conceptual features that are similar to those encountered by Kekulé in his resolution of the structure and valence of benzene. Like Kekulé, the problem arose from a contradiction between two principles. The first principle, derived from classical mechanics, was that the laws of motion were the same for all bodies when moving at a constant velocity; the principle of *relativity*. The second principle, derived from Maxwell's laws of optics, states that the propagation of light, in an inert system, remains *constant* at a velocity of 300,00 kilometres per second (c). The problem posed for Einstein was that whilst both principles appeared to work adequately they contradicted each other to the extent that the first was a statement of the relativity of velocity and the second of the constancy of the velocity of light.

The majority of physicists working at this time preferred to ignore this problem (Penrose, 1989). After all, Newtonian physics successfully predicted the motion of everything except light. However, several experiments (Michelson, 1882; Michelson & Morley, 1887; cited in Lorentz 1895/1923) reinforced the validity of the Maxwell equation. Einstein resolved the problem by turning in part to Gedanken experiments (thought experiments) whereby laws are applied to the variable under investigation and the outcome is monitored by the imager (Epstein, 1965; Miller, 1989, 1992; and Shepard, 1978a). To understand the importance of this use of mental imagery in the development of the special theory of relativity it is necessary to review the role of experimentation in physics and the problem faced by Einstein.

The experimental method was developed in the sixteenth and seventeenth centuries as a refutation of common sense science. The writings of Bacon, Hobbes, and Locke set forth a new agenda for investigating the natural form and order of matter. According to this view it was necessary to cast aside the 'idols' and 'false images' which prejudice the true understanding of nature and to advance a new practice of induction (Hesse, 1964). The method was based upon the combination of a mechanistic perception of nature and the systematic investigation of both the positive and negative instances of the occurrence of the phenomena under study.

This new method was exemplified in the work of the great physicists of the period, i.e. Galileo and Newton, who developed, through mathematics and experimentation, classical mechanics. The superiority of experimentation over common sense appears constantly in the work of these men. Galileo, for example, uses Simplicio (an Aristotelian) to show that the mistakes made by Aristotle reside in his failure to adopt an inductive principle for investigation. While there is no proof that Galileo conducted the free fall experiments from the tower of Pisa there are many example of the use experiments to confirm hypotheses in his publications and even to develop hypotheses in unpublished manuscripts (Cohen, 1987). Newton was also bound by the experimental philosophy of the day. He was so committed to the inductive method that when he proposed his theory of universal gravitational attraction he was compelled to deny it the status of a scientific theory (Newton, 1687/1981).

By the eighteenth century the empirical methods employed by physicists had become the dominant procedure in the natural sciences. The correct prediction of the arrival of Halley's comet in 1758 by Newton in 1667 produced the ultimate verification of the scientific method espoused by Bacon. In the late nineteenth century, however, a culmination of experiments disrupted the mechanistic world view. Faraday and Maxwell demonstrated the existence of electromagnetic phenomena which did not conform to the Newtonian model. Maxwell's propagation of light equations and the experiments of Michelson and Morley contradicted the Galilean principle of relativity.

The fundamental problem was that whilst the technology available was capable of disproving the classical position it was inadequate at the investigative stage. As a consequence physics engaged in a process of reformulating the old system in accordance

with the contradictions found in the new experiments. A similar situation had occurred with the transition from the geocentric to heliocentric systems only this time there was no telescope to act as a catalyst for a new system.

While the empirical method was the dominant paradigm of investigation in physics an alternative mode of thinking was also popular in Germany, *gewohnliche Anschauung*, which was the antithesis of the method proposed by the Empiricists. *Anschauung* involved the use of visual mental imagery to represent abstract phenomena in physical space. As Miller (1989) states:

"*Anschauung* is the visual mode of representation that is based on abstractions from phenomena actually witnessed in the world of sense perceptions. For example, the visual image of magnetic lines of force was raised to an *Anschauung* by most electrical engineers in the German cultural environment. They assumed that magnetic lines of force are an integral part of electromagnetic theory, rather than just an aid to visualisation as was believed by the vast majority of American and British engineers." (Miller, 1989, p. 172).

Thus, Einstein was brought up in an environment where the use of mental imagery was encouraged not just as a way of visualising but as an essential aspect of the physical system under investigation.

Einstein went further than visualising the known phenomena of the period. He also used the *Anschauung* to construct and test hypotheses. Einstein referred to these thought experiments as *Gedanken* experiments. This use of mental imagery is summarised by Epstein:

"*Gedanken* experiment is Einstein's German expression for a thought experiment. It is an experiment you carry out in your head. You can do it because you also have in mind all the laws governing the events you visualize." (Epstein, 1965, p. 33).

The emphasis upon visual thinking by Einstein has been well documented by Hadamard (1945), Shepard (1978a), Miller (1986, 1989, 1992), and many others. A brief review of his work reveals numerous uses of *Gedanken* experiments (Einstein, 1920) to describe his theories. Below are several examples:

Example I: Illustrating the system of co-ordinates developed by Descartes:

"If, for instance a cloud is hovering over Trafalgar Square, then we can determine its position relative to the surface of the earth by erecting a pole perpendicularly on the Square so that it reaches the cloud. The length of the pole measured with the standard measuring-rod, combined with the specification of the position of the foot of the pole, supplies us with a complete place specification." (Einstein, 1920, p. 6).

Example II: On the notions of space and time in classical mechanics:

"I stand at the window of a railway carriage which is travelling uniformly, and drop a stone on the embankment, without throwing it. Then, disregarding the influence of air resistance, I see the stone descend in a straight line. A pedestrian who observes the misdeed from the footpath notices that the stone falls to earth in a parabolic curve." (Einstein, 1920, p. 9).

Example III: On the contradiction between the speed of light and the principle of relativity:

"...let us again choose our embankment. We shall imagine the air above it to have been removed. If a ray of light be sent along the embankment, we see from the above that the tip of the ray will be transmitted with the velocity c relative to the embankment. Now let us suppose that our railway carriage is again travelling along the railway lines with the velocity v , and that its direction is the same as that of the ray of light, but its velocity of course is much less. Let us inquire about the velocity of propagation of the ray of light relative to the carriage." (Einstein, 1920, p.18).

In summary Einstein's use of mental imagery went against the method of induction advocated by the Empiricists and used by the classical physicists in the sixteenth and seventeenth centuries. The predominant context in which the images were used was in the development of *Gedanken* experiments. These were actively produced by

Einstein. It can also be surmised that Einstein had much control over his images, especially as they contained many constraints imposed by the imager.

The Problem Domain: The Contradiction Between the Principle of Relativity and the Propagation of Light in vacuo

The special theory of relativity is concerned with the laws of moving bodies (Einstein, 1905/1923). It is called the “special theory” because it refers to only one aspect of motion. This is the uniform motion of bodies in inertial reference frames, that is, objects that are either moving at a constant velocity or are resting. It wasn't until a decade later, when Einstein completed his general theory of relativity, that a General design for all bodies in motion was developed.

Prior to the publication of the special theory of relativity in 1905 the prevailing theory of the uniform velocity of bodies was that proposed by Newton, the principle of relativity. The principle of relativity, also known as Galilean relativity, is simply that all uniform motion is relative to the position of the observer. Several features emerge from the principle of relativity, the most fundamental of which is that we are unaware of the motion of the earth despite the fact that it orbits around the sun at 100,000 kph. The proof of this unperceived motion is given through Galileo's *ship at sea* experiment in which it is demonstrated that the position of the observer is crucial to determining the nature of movement. A contemporary equivalent of this experiment is given by Epstein:

"Suppose you are flying along smoothly and standing inside an aircraft cabin... and you drop a coin directly above your toe. Sure enough it hits your toe... the central idea is that if you are closed inside a box that is moving smoothly... you cannot tell if you are in motion." (Epstein, 1965, p.2).

If the principle of relativity is extended to the measurement of velocities then further features arise. The most important of these is that the speed of any body in motion can only be measured relative to an observer or a reference point in the locality of the observer. Suppose you are travelling at a constant velocity (300kph) but you are not aware of this because you have no means of discerning your movement; a quiet aircraft travelling at night could give this impression. What you do have is a device for measuring the speed of other objects. In the first situation an object approaches you from the

opposite direction at 400kph and you measure its speed. You find, however, that it is travelling at 700kph because your only means of measuring its speed is relative to yourself ($V' = 400\text{kph} + 300\text{kph}$). In the second situation an object travelling in the same direction as you passes you at a constant velocity of 400kph. Again you measure its speed but this time you conclude that it is travelling at 100kph ($V' = 400\text{kph} - 300\text{kph}$). Although the objects were travelling at the same speed you can never discern this because you can only measure their velocities relative to your own direction and velocity. This is the principle of relativity and, until the late nineteenth century, it proved to be a very useful means of measuring the motion of all bodies.

There is one further aspect of the system which has not been discussed. This is the concept of a medium through which bodies travel, namely, ether. The notion of ether was initially proposed by Newton. It was necessary in order to explain the mechanistic laws underlying nature. It explained how light travelled from the sun to the earth, why the earth orbited around the sun, and why the moon orbited around the earth. Ether was crucial to Newton's General Design. If it could be detected then it would provide the only absolute measure of uniform velocity, which paradoxically would also have the effect of both destroying and explaining the principle of relativity.

As it was believed that light travelled in ether most physicists assumed that its velocity was finite. In accordance with the Newtonian world view it was also postulated that light was made up of particles and that these particles obeyed the same laws of motion as other particles (i.e. the principle of relativity). However, the study of optics proved to be a Pandora's box for classical mechanics. Every time optics was investigated it challenged the previously held assumptions. The particle theory of light was first challenged by Grimaldi's discovery in the sixteenth century that light produced flow effects; suggesting that it had a wave formation. Although a wave theory of light presented problems for classical mechanics it was quickly incorporated into the General Design. After all, if sound propagates in wave formations through the compression of air, its medium, there is no reason why light shouldn't behave the same way in ether.

During the nineteenth century an extensive understanding of the laws of optics was developed by Ampère, Faraday, Hertz, and Maxwell. It was found that light behaved in a similar way to electromagnetic bodies and that these forces act according to fields of force. Faraday showed that force fields were real physical things. Maxwell developed a

series of equations that explained the propagation of light with the implication that the speed of light was constant in space. Nevertheless, the mechanistic view was upheld. However, by this time it had become a far more complex system than Newton had initially envisaged.

The real dilemma for physics came about as a consequence of the development of experimental techniques in the late nineteenth century. Technology had progressed to the extent that it was possible to measure the effects of ether. Ether, it is recalled, is an all pervasive stationary substance through which all matter moves. If a body was moving at a sufficient force (the earth) it seemed reasonable to assume that this would have a displacement effect upon the ether and that this displacement would influence the motion of particles (light) travelling through it. However, when experiments were conducted that would detect the effects of ether-drift upon the motion of light (notably those by Michelson in 1881 and Michelson & Morley in 1887) it was found that its speed remained constant

The findings of these experiments puzzled the scientific community. The most common explanations for the results were either to criticise the experimenters or to explain the findings in terms of a contraction hypothesis (Lorentz, 1895/1923). The contraction hypothesis, independently proposed by Fitzgerald and Lorentz (Lorentz, 1895/1923), postulates that, just as matter flattens upon impact, it also contracts with the force of ether movement. Except for Einstein, few considered the possibility that ether did not exist as this would have thrown the Newtonian system into disarray.

This is the problem domain up to the point of Einstein's special theory of relativity. The obvious strategy to take in the face of this dilemma was to reject one of the principles underlying the problem. That is, either the principle of relativity is wrong or the velocity of the propagation of light *in vacuo* is wrong. Einstein chose to do neither. His reasoning was derived from a faith in both principles and the application of *Gedanken* experiments to reason through the consequences.

Einstein did not wish to dispose of classical mechanics as it provided a very powerful means of making predictions. These had proved to be accurate in respect of all matter except electromagnetic phenomena. As he states:

"Even though classical mechanics does not supply us with a sufficiently broad basis for the theoretical presentation of all physical phenomena,

still we grant it a considerable measure of "truth," since it supplies us with the actual motions of the heavenly bodies with a delicacy of detail little short of wonderful. The principle of relativity must therefore apply with great accuracy in the domain of *mechanics*." (Einstein, 1920, p.14).

Neither did he wish to countenance the laws of optics derived from Maxwell's equations for it was clear to him that they were correct. This is demonstrated in a *Gedanken* experiment he first conceived of in 1895 in which he imagined the consequences of catching up with a light wave (Miller, 1989). It was obvious to him that if an observer did catch up with a light wave it would, according to the principle of relativity, appear static. Yet light can never appear static because it is derived from an electromagnetic source which is self-sustaining. Therefore, the constancy of light *in vacuo* must be maintained.

If light has a constant speed and the principle of relativity concerning velocity is correct then the only other factor that determines the velocity of an object, that is time, must be relative. This is a radical departure from the Newtonian concept of the absoluteness of time, however, Einstein had found the basis for the preservation of both principles. As he states:

"As a result of an analysis of the physical conceptions of time and space, it became evident that *in reality there is not the least incompatibility between the principle of relativity and the law of the propagation of light*, and that by systematically holding fast to both of these laws a logically rigid theory could be arrived at." (Einstein, 1920, p. 19-20).

Here we have the development of a fourth-dimension in the principle of relativity. While the first three dimensions provide an accurate, though wrong, measurement of the velocity of most forms of matter when they are applied to objects approaching the speed of light a fourth factor must be considered, namely time. Finally, there was no longer any reason or logic in supposing the existence of ether as light *in vacuo* formed the bedrock of the new theory.

In summary, Einstein succeeded in resolving the apparent contradiction between two principles, the principle of relativity and the constancy of the speed of light relative *in vacuo*, by applying thought experiments. His dependence upon these thought experiments

was crucial. This is evident in both, the revolutionary nature of what he was proposing, and the limitations in developing a new system from purely inductive methods.

Similar Problems, Different Mental Imagery Heuristics

These case studies provide two insights into the nature of the relationship between mental imagery and creativity. The first is that any attempt to impose a general heuristic will fail to cover the full scope of the relationship between mental imagery and creativity. The second is that despite the similarities in the problem domains for Kekulé and Einstein, the actual application of mental imagery is contrastive. This suggests that the use of mental imagery is dependent upon the individual and the problem structure.

In reviewing the uses of mental imagery by Kekulé and Einstein the differences between them are striking. Kekulé's use of mental imagery can be summarised as passive and prophetic, in contrast Einstein's mental imagery is active and deductive. Yet there are noticeable similarities in both, the areas they were working in, and the conceptual structure of the problems and solutions they arrived at. Both Kekulé and Einstein were working in a similar time period when the old order was being challenged by new discoveries. The inductive method was predominant and the areas were changing so rapidly that constructive information was limited. There is also a great amount of similarity in the problems presented to them. In both cases there was a contradiction between two established principles. For Kekulé this was the contradiction between the known valence and structure of carbon atoms. For Einstein it was the contradiction between the speed of light and the principle of relativity.

The resolutions reached by Kekulé and Einstein were also alike. The two of them succeeded in preserving the foundations of the principles that contradicted each other. Furthermore, both solutions were derived from a hypothetico-deductive method, that is, they were formed prior to testing. Finally, they also made predictions that went a long way beyond the known reasoning of the time; both of which were found to be correct when the technology was available.

Given all of these consistencies it is surprising that the use of mental imagery was so different. Clearly, any study into the relationship between mental imagery and creativity is going to require a systematic investigation into the full spectrum of context, content, control, and vividness of mental imagery.

Conclusion

This chapter has attempted to demonstrate the complexity of the relationship between mental imagery and creativity. Having investigated the use of mental imagery by historically creative individuals it is clear that no single imagery heuristic will explain the link between the two processes. To date there is a clear disparity between the reports of these individuals and the empirical research carried out by mental imagery researchers. Whilst creativity remains a *raison d'être* for the study of mental imagery, until a full and systematic review is carried out it will also remain a mystery.

Chapter II

What is a Mental Image? On the Apparent Contradiction Between Creative Enhancement and Perceptual Equivalence

Introduction

The previous chapter suggested that mental imagery has been frequently reported by historically creative individuals. It also argued that because there were many ways in which mental imagery could be used in the creative process, a single imagery heuristic could not account for the role of mental imagery in creativity. Having established that mental images are frequently reported in the historical process, the aim of the present chapter is to address an apparent contradiction between these reports and contemporary conceptions of mental imagery. If mental images can lead to creative enhancement then a definition of mental imagery must go beyond the various perceptual equivalence hypotheses stated by cognitive researchers. Because of this apparent contradiction it is necessary to develop a new definition of mental imagery that allows for the use of mental images in the genesis of creative ideas and properly distinguishes percepts from mental images. The consequences of redefining mental imagery, however, are severe, with some phenomena traditionally defined as forms of mental imagery being removed from the category.

In the late 1960s and throughout the 1970s mental imagery research burgeoned. The driving force behind this development was the debate over the representational status of mental images. Inevitably, the inventive experimental protocols that emerged focused almost exclusively upon what is commonly referred to as ‘the perceptual equivalence hypothesis’ (Finke, 1989). The zooming, scanning, and rotating studies were all designed to demonstrate that mental images are ‘percept-like’ and that they shared the same mechanism as perception.

Since this extremely productive period of cognitive psychology, the focus of research into mental imagery has moved more toward the neuropsychological structure of mental imagery; the same motivation, however, remains. In the periphery of this research, however, many of the leading researchers of cognitive psychology have turned their attention to some of the extraordinary aspects of mental imagery. Some of the authors of seminal papers into the perceptual equivalence of mental imagery went on to herald the unique status of mental imagery in creative processes. Shepard (1978a) claimed his motivations for studying mental imagery were based upon its use in creativity. Paivio (1983) reviewed the role of mental images in the development of history-making creativity and Finke (Finke, 1990; Finke and Slayton, 1988) outlined and developed a

research profile that involved the use of mental imagery in the development of creative ideas.

It is evident from the reports of these researchers and others (e.g. Daniels-McGhee and Davies, 1994; Ghiselin, 1952; and Miller, 1992) that there is at least strong anecdotal support for the role of mental imagery in creativity. What is not clear, however, is how these reports can be placed within the almost uniform definitions of mental imagery put forward under the auspices of the perceptual equivalence hypothesis.

Broadly defined the perceptual equivalence hypothesis states that mental images are equivalent to percepts in a variety of ways (see Finke, 1980, 1985, 1989). They may, for example share the same mechanisms as percepts, the same function as percepts, or the same structure as percepts. Demonstrations of perceptual equivalence have primarily focused upon visual imagery and equivalence has been suggested in: visual acuity and overflow (Finke and Kosslyn, 1980; Finke and Kurtzman, 1981; Kosslyn, 1978); mental comparisons (e.g. Paivio, 1978ab); mental rotation (Shepard and Metzler, 1971; Cooper and Shepard, 1973); mental scanning (Finke and Pinker, 1982; Kosslyn, 1973; and, Kosslyn, Ball and Reiser, 1978) and, somewhat controversially in imagery illusions (Broerse and Crassini, 1983; Brosigle, Chan, Brandt-Tiven, Miller, and Sanders, 1997; Peterson, Kihlstrom, Rose, and Glisky, 1992).

It is beyond the scope of this chapter to propose a detailed account of the role of mental imagery in cognition (see Chapter Three). Nevertheless, it is necessary to provide a foundation upon which the nature of the role of mental imagery in creativity can be understood. To achieve this a review and revision of an aspect related to the second imagery debate (Kosslyn, 1980, 1981; Pylyshyn, 1973, 1983) will be conducted. This concerns the construction of a proper definition of mental imagery.

A common objection to the general study of mental imagery is that a mental image can sometimes mean apparently everything and anything to those employing it. Certainly, many of the problems associated with the area can be attributed to a failure to develop an adequate description of mental imagery. This criticism formed an important thrust of Pylyshyn's first attack upon mental imagery research (Pylyshyn, 1973) and is acknowledged by many who posit a functional role for mental images (e.g. Kosslyn, 1980). It is therefore necessary to develop a sufficient account of what a mental image is and what a mental image is not. This is a controversial task. As will be shown, many of

the experiences traditionally enveloped in the term “mental imagery” can be excluded as irrelevant.

The Picture-in-the-head Metaphor

The simplest definition of the experience of having a mental image is that it is a ‘picture in the head’. This definition is part of a group of perceptual metaphors that have traditionally been used to describe processes related to mental imagery. Other examples include, a ‘mind's eye’ to describe a process akin to seeing, and a ‘theatre in the mind’ to demonstrate the closeness of mental images to the representations of their external referents. These metaphors can be traced from Plato to Descartes, and later to the work of the British Empiricists (e.g. Berkeley, Hume, and Locke) who viewed mental images as the bedrock of all mental representation; Hume, for example, referred to the mental image as the “mother of representations” (Flew, 1964).

In all of these metaphors the underlying aim is to describe the perceptual quality of having a mental image. In the context of British Empiricism it also describes a doctrine of thinking which posits a dichotomy between perceptual and linguistic processing. These terms are couched in Cartesian conceptions of knowledge representation and, even as metaphors, are an easy target for physicalist arguments against mental imagery. Block (1983) lists three common objections to the mental imagery construct that are essentially derived from the picture-in-the-head metaphor. These are: the *noseeum* objection, that if you look inside somebody's head you do not see a picture; the Leibniz Law objection, that for a thing to be identical to another thing it must share all of the properties; and the paraphernalia objection, that to have a picture-in-the-head would require an internal eye to see the picture, ad infinitum. All of these objections apply specifically to the picture-in-the-head metaphor and the quotation below is typical of the physicalist arguments used against them:

"Whatever mental images may be.. There is no small theater in the head where these images are projected on a screen, and there is nobody there to look at them anyway." (Goodman, 1986, p.359).

Although the picture-in-the-head metaphor can easily be refuted by physicalist arguments, and it enjoys frequent usage by iconophobes (see Kosslyn, 1980), it is rarely used by those who advocate a role for mental imagery in information processing. Indeed,

Kosslyn (1980) claims that the picture-in-the-head account can be summed up as a *straw man* and of little relevance to modern research into mental imagery.

The problem with the picture-in-the-head metaphor is that it arises from a misunderstanding of what a person means by a picture-in-the-head. Block (1983) provides illumination as to how this misunderstanding arose. When a person claims that their mental image is like a picture-in-the-head they do not mean that it is like a picture hanging on a wall. Likewise, when a person states that they can see a 'real' picture they do not have a picture-in-their-head. What they are really trying to say is that the experience of having a mental image is similar to the experience of seeing a picture. Viewed in this way the picture-in-the-head account of mental imagery can be seen for what it is, a metaphor that aids understanding. To take the metaphor too literally is to misconstrue and misapply the use of metaphor. However, if the aim is theory precision then the use of this metaphor is inappropriate when attempting to define mental imagery.

More Recent Conceptions: The Misuse of the Percept Metaphor

While the picture-in-the-head definition of mental imagery is rarely used, it shares a common currency with its successors in that it describes mental imagery as a percept-like experience. This has become the accepted definition of mental imagery. While Watson was driven to rejecting the existence of mental images in his behaviourist manifesto (Watson, 1913) even those “modern iconophobes” who dismiss mental images as epiphenomenal experiences acknowledge their relationship to percepts. Pylyshyn, for example, in his second seminal critique of mental imagery, explicitly acknowledges the conscious experience as perception-like:

"The study of mental imagery continues to be a major concern in cognitive psychology. Since regaining acceptance about 15 years ago, the study of processes underlying the sort of reasoning that is accompanied by perception like experiences has become one of the most focal points of the new mentalistic psychology." (Pylyshyn, 1981, p.16).

Thus, contemporary conceptions of mental imagery continue to view it as a percept-like experience. There are still the occasional uses of metaphorical thinking especially when the term is linked to the role of mental images as explanatory constructs (Pylyshyn, 1973).

Generally though, the metaphorical uses can be reinterpreted, as Block (1983) suggests, or ignored because they go beyond an initial definition.

In surveying the variety of definitions of mental imagery proposed by the “iconophiles”, two inadequate ways of defining mental imagery emerge. The first way is to ignore the need to define mental images. This is the operational method of defining mental images. Kosslyn (1980, 1994), for example, simply asks the reader to picture the shape of a dog’s ears. Shepard (1966) requires the reader to count the number of windows in their house. Finke (1985) asks the reader to visualize a recent acquaintance. Presumably, this method is deemed to be sufficient enough to demonstrate the similarity between mental imagery and perception. Unfortunately it falls short of defining a resemblance or even why there should be a resemblance. Consider, for example, the sufficiency of such a demonstration if the same rule were applied to a definition of language. Furthermore it fails to encompass the enormous range of types of mental imagery, many of which vary markedly from the simple examples given.

The second method is to describe mental images in such a way that no real definition is given at all. An example of this is given by Finke who defines a mental image as:

"The mental invention or recreation of an experience that in at least some respects resembles the experience of actually perceiving an object or an event, either in conjunction with, or in the absence of, direct sensory stimulation." (Finke, 1989, p.2).

If the ambiguity in the initial premise is ignored, a first reading of this account might give the impression of being reasonably lucid. Finke evidently believes it is sufficient. In fact he goes on to state that it, "... is a convenient working definition for the scientific investigations that will be reported here" (Finke, 1989, p.2). All that can really be concluded from the statement, however, is that mental imagery 'resembles' perception. Nothing much is said of how mental images resemble percepts, or more importantly how they differ from percepts. The reference to sensory stimulation provides little insight as it lacks specificity. In summary, it goes no further than describing mental images as being similar to percepts.

Finke's perceptual definition of mental imagery is commonplace in the field. Most accounts rarely go beyond defining the experience of having a mental image as being

similar to perceiving. Of course, it could be argued that there really is no need to go beyond the percept-like description of mental imagery. According to this argument the terms 'mental' and 'image' provide the basic ingredients for defining the phenomenon. In other words, the term 'mental imagery' is sufficiently self-descriptive. However, there are several reasons, both general to mental imagery and specific to the current chapter, why it is necessary to go beyond this basic description.

The first problem with employing only a cursory account of mental imagery is that it is very easy to make category mistakes when describing the different forms of mental imagery. The vagueness of mental imagery can result in either an over-generalization or an under-generalization of the term. Horowitz (1970), for example, makes the over-generalization mistake when providing a classification of mental images. Many of the examples he provides (e.g. visual illusions) are clearly more representative of perceptual images than mental images. This error is grounded in a misunderstanding of the nature of perception which Horowitz appears to assume is always veridical. Such a 'realist' view of perception would not be expected from constructivist approaches to perception (e.g. Gregory, 1970; and, Rock, 1983), but even the direct perception of Gibson (1979) would not go so far as to state that percepts are defined as 'what is out there' and therefore everything else is a mental image. Although this is not stated by Horowitz it is one possible conclusion to be drawn from his classification system.

The under-generalization problem is never made explicit but is fundamental to the imagery debate. Typically it employs an intentionality criterion. Either, requiring somebody to image a house or implying another intentionality criterion ('the mental invention or recreation') leads to a contraction in what is defined as a mental image. Though rarely made explicit, the evidence to support an intentionality criterion in modern mental imagery research is very compelling. The best known experimental protocols for image generation and manipulation (mental rotation, mental scanning, and illusions) have generally ignored all forms of mental imagery but images associated with thought. The best known theoretical approaches also appeal mainly to thought images (Kosslyn, 1980, 1994; Paivio, 1971; Shepard, 1984) and even the best documented accounts of the role of mental imagery in creativity emphasize the role of thought images (Finke, 1989, 1990; and Shepard, 1978a). In summary, under-generalization and a narrowness in definition

and methodology are rife in the field of mental imagery. Part of the reason for this appears to be the persistence of the percept-like metaphor.

The second problem is related to Pylyshyn's (1973) attack upon the use of mental images as explanatory constructs. One of Pylyshyn's original arguments against mental imagery being used in scientific investigation was that the concept was too vague. He went on to claim that a primitive explanatory construct must be clearly and precisely defined in order for its operations to be fully understood; logical predicates, it was argued, were well defined. Kosslyn (e.g. Kosslyn and Pomerantz, 1977), countered this critique of mental imagery by stating that in its formative years it was not necessary for a term to be well defined. Miller (1978) claims that the differences between Pylyshyn and Kosslyn emerge from differing priorities; Pylyshyn is concerned with theory development and Kosslyn with theory demonstration. Perhaps Kosslyn was right in his assumption that new areas need time to develop but it is now twenty-two years since he argued in favour of the vagueness of the mental imagery construct. Mental imagery is in its fourth decade of research since the 'cognitive revolution' and yet the underlying theory remains speculative and incomplete. This is not because researchers have failed to demonstrate the existence of mental imagery so it must be assumed that there was (and still is) some element of truth in Pylyshyn's criticism concerning the lack of theory precision.

A compelling reason why mental imagery requires a precise definition is related to any potential role of mental imagery in creativity. As was noted, there are many reports of the use of mental imagery in creativity (Daniels-McGhee and Davies, 1994; Ghiselin, 1952; and, Paivio, 1983) and in the last decade an experimental protocol which demonstrates the emergence of creative forms and inventions in an imagery task (Finke, 1990). If mental imagery plays a role in creativity then it must be more than a percept-like experience; or at least have some properties that are different from those of perception. This is because even the most ardent advocate of the constructivist approach would not venture to propose a creative role for the process of perception. For example, Rock (1983), who views perception as an intelligent process states that he does not regard percepts as having the property of creativity. The following account by Rock of the problem solving abilities inherent in perception testifies to this:

“ ‘Inference’ seems an apt description of what is going on here because the system must infer or deduce a conclusion given certain premises. As

in syllogistic reasoning (or general predicate logic) the terms in different premises are related to one another. Yet even in such cases it would not seem appropriate to describe the process as creative problem solving any more than it would when we draw the conclusion based on transitivity that if $a > b$ and $b > c$, then $a > c$." (Rock, 1983, p.13).

The fact is that any theorist who claims that mental imagery is important in the creative process must assume that mental imagery involves more than perception *per se*. There must be something additional or different that enables the creative process to occur. Yet, rarely do researchers go beyond the basic percept-like definition. The suggestion that the reader picture his/her house, scan an image, or rotate an image all suggest a stable entity or activity that excludes fluidity, flexibility and originality, the hallmarks of creativity.

Only a small sample of definitions of mental imagery have been provided here. Nonetheless, these examples illustrate the general types of problems inherent in the research area. Given these difficulties it is hardly surprising that mental imagery is frequently deemed to be a vague term. What is required is a thorough consideration of the aspects that combine to make a mental image and, more importantly, to investigate what makes mental images *different* from percepts.

Percepts and Mental Images

As there has been a strong historical association between the constructs of perception and mental imagery the first objective must be to evaluate this relationship. That is, for what reasons has perception been chosen as the most apt analogy for mental imagery? Once these reasons have been clarified it will be possible to describe the relationship between percepts and mental images and, in so doing, create a dichotomy between the two types of experiences. The method adopted here is to define the concept of a percept and from this position conduct a contrastive analysis between the two types of experiences similar to that proposed by Baars (1988) in his development of a theory of consciousness. First, however, it is necessary to uncover the reasons mental images have been associated with percepts.

There are several reasons why imagery theorists have emphasized the association between perception and mental imagery. The predominant reason has little to do with the

phenomenological experience of having a mental image and a lot to do with the debate pertaining to the representation of mental images. This hypothesis posits an “equivalence” between percepts and mental images. One motive for this is the belief that if it can be demonstrated that a mental image has both a structure and/or function equivalent to (or, at least, similar to) perception then it can be concluded that mental images are analogical representations. The problem with this supposition is that it cannot necessarily be assumed that percepts are analogical representations (Block, 1983).

Despite knowing the Block argument against the perceptual equivalence hypothesis there is an additional underlying motivation to demonstrate a relationship between mental imagery and perception. The connection between perceptual equivalence and analogical representation was suggested by Pylyshyn (1973) in his 'tacit inference' critique of mental imagery experiments. Mental representation lies in the background of all imagery-perception studies and there is a direct correspondence between the positions of analogical/logical representation and perceptual/artifact explanations of perceptual equivalence. It is, after all, far easier to conceive of analogical representations within a perceptual system than outside of it. If there is truth in Anderson's (1978) claim that the imagery-propositional debate is irresolvable, there is nowhere else to turn.

Though the emphasis of the research is upon the development of a cognitive model of mental imagery as functionally and/or structurally equivalent to perception, the original justification for using a perceptual analogy for imagery was the phenomenological similarity of the two experiences. This stems from the position of the British empiricist philosophers, Hume and Locke. The experiential similarities between mental imagery and perception suggest a shared form of representation in consciousness, namely, an analogical one. In other words, mental images, like percepts, are part of a group of phenomena that are expressed in a non-linguistic or non-propositional mode (or what at least appears so to the experiencer). To “have a visual image” is akin to seeing yet it is not seeing because there is no immediate external referent out there to see.

As a motivation for studying the association between mental imagery and perception, the latter reason seems more justified than the former but it doesn't carry the same implications for it admits to a difference between the two experiences. In reviewing the research into the shared properties of mental images and percepts, Finke (1985) outlines three theoretical stances: structural theories; functional theories; and interactive

theories. All emphasize the former reason as opposed to the latter. A by-product of this emphasis upon architectural structure and function is that it has become an article of faith for the exponents of mental imagery to advance the similarities between perception and mental imagery and to downplay the differences. In this circumstance it is difficult to impart a distinction between the two experiences. While there are striking phenomenological resemblances between mental images and percepts, there are also very obvious differences.

The Function of Perception

Definitions of perception are as problematic as those of mental imagery and equally dependent upon the theoretical ideology underlying them. Nevertheless, it is the author's belief that there is at least enough known about perception - and sufficient conformity - to distinguish it from mental imagery on the basis of function.

The traditional concept of perception is of an information receiving device, a 'window' through which the external world is given. Reformulations, however, have rejected the notion of the perceiver as a passive recipient of sensations. Contemporary conceptions of perception all agree that the individual is active in the 'seeing' process. In essence there are two contrasting schools of thought, one which focuses upon the experience of perceiving (Gregory, 1966; Marr, 1982; and Rock, 1984), and the other which emphasizes an action-oriented direct perception (e.g. Gibson, 1950, 1979). Both approaches imply a function for perception, though this is not made explicit in the ecological approach.

The former approach is very clear about the function of perception, claiming that perception serves to provide meaning to the external world, what Rock (1984), following Bartlett (1932), refers to as the constraint of *effort after meaning*. Here perception is seen as constructive in the sense that a hierarchical information process (a bottom-up approach) is carried out on a two-dimensional retinal image (e.g. Marr's 2-1/2 dimensional sketch: Marr, 1982). The ecological approach also posits a function for perception. According to Gibson (1979) the role of perception is *information pickup*. Not the picking-up of individual stimuli but of a stimulus flux. This leads to an act-based psychology in which behaviour and environment are closely wedded.

Although there are major differences between these two approaches, in both accounts one can find essentially the same factor that serves to distinguish a percept from a mental image. In both cases the central defining characteristic of perception is that it is compelled by its purpose. Whether it is to discern meaning (the computational approach) or to act upon the environment (the ecological approach) perception cannot be detached from its function. Furthermore, these are not consciously determined processes, as is the case with thought-invoked images, but are evolutionarily driven automatic processes.

In both approaches therefore perception cannot be separated from the constraint of purpose and it is this circumstance that creates the phenomenological characteristics of perception. At a functional level it is not thinking that governs the appearance of a percept but automatic processes operating on the optical array. In the case of the computational approach perception can therefore be said to be subservient to the proximal stimulus. In the ecological approach there is also subservience, but according to this model, perception is the slave of stimulus flux. Here lies the rule for differentiating percepts from mental images.

Distinguishing Mental Images from Percepts

How should mental imagery be understood in this context? The method chosen here is to investigate the correspondence between mental images and percepts as being analogous to the correspondence between inner speech and actual speech. This is useful because it is far easier to conceptualize the correspondence and the distinction between the two forms. In both cases there is a shared phenomenal representation and an identical method of conceptualization. In the case of inner speech and actual speech the phenomenal representation and conceptualization are linguistic; with mental imagery and perception the phenomenal representation are pictorial. An earlier statement of this analogy was presented by Marks (1977, Figure Two, p.278) in discussing a model of consciousness and visual cognition.

There are further resemblances between mental images and inner speech on the one hand and perception and speech on the other. For example, both speech and perception have specific functions, whereas inner speech and mental imagery do not. Speech and perception also have designated organs through which their functions are

achieved: the vocal tract and any number of sensory channels. Conversely, inner speech and mental imagery do not require an organ in order to be instantiated.

Clearly, there are differences between mental imagery and perception, just as there are obvious differences between inner speech and actual speech. However, just as inner speech is defined in the context of its more discernible counterpart, so too is mental imagery. This does not mean that inner speech is actual speech but that it is language without speaking. Thus, mental imagery can be defined as anything that is expressed in the form of a percept but is not a percept. This is obvious, yet it is seldom the case that perception is considered in this way by mental imagery theorists. This, then is how mental images should be understood.

Finally, it may be argued that mental images are instantiated from a proximal stimulus/stimulus flux; just as inner speech is instantiated by communication. However there are fundamental differences. With a mental image the perceptual stimulus acts only as a cue and the proceeding experience is constructed from knowledge rather than the immediate environment. Thus, percepts and mental images can be seen as two discrete categories of a phenomenological experience. Percepts are a set of experiences that are constrained by an effort to find meaning and/or act-upon the environment. Mental images are anything else that activates analogical representation. In other words, phenomena which trigger the same representations (or codes) that are triggered by perception, but in the absence of perception. They range from 'looking at' experiences (e.g. dreaming, hallucinations) that are similar to percepts, but do not possess the condition of interpretation of proximal stimuli/information pickup, to the intelligent 'looking for' experiences conjured during goal-oriented operations (e.g. mental transformations).

In summary, mental images have traditionally been associated with percepts. The main reason for this is that they share the same system of phenomenal representation. Perception is concerned with information interpretation (the computational approach) or information pick up (the ecological approach). In both cases percepts are constrained by their function. While mental images resemble percepts they differ in ways that are similar to the differences between inner speech and actual speech. Fundamentally, they are not generated by stimulation of a sensory organ, and as such do not have the accompanying constraints. Just as inner speech is language code activation without actual communication, mental imagery is perceptual code activation without actual perceiving.

The Consequences of the New Definition of Mental Imagery

The consequences of applying this definition of mental imagery to the present thesis are advantageous. By recognizing both the similarities and the differences between mental images and percepts it is possible to avoid confusion caused by category mistakes and also by under or over-generalization. This also has an important effect on the investigation of the role of mental imagery in creativity; recall that even the most ardent supporters of intelligent perceptual processing have to deny that perception is creative (Rock, 1983). In effect, the majority of experiences that are cast as either sensations or percepts according to the present definition have very little association with creativity. Only mental imagery, it is argued, which is unconstrained by the functional characteristics of perception, can possibly play a role in creative processes.

As was noted, some of the errors that have occurred in defining mental images can be attributed to a misunderstanding of perception (e.g. Horowitz's, 1970, classification). The earlier consideration of perception highlights an error regularly made when apportioning phenomenological experiences to perception. This is to assume that perception is simply a window through which the external world is passively represented. As has been shown, neither of the dominant paradigms construe perception in this way. Thus, if a criterion has to be invoked then it is far better to employ that of function (i.e. 'effort after meaning' or 'information pick-up'). Experiences such as illusions may not be 'out there' but it would be very difficult to argue that they do not arise from the function of perception, regardless of the approach adopted.

If the rule is applied that percepts are constrained by function and that mental images are those experiences which share the same mode of representation but lack this constraint, then many of the experiences which are commonly referred to as mental images require re-classification. For example, almost all of the experiences classified as 'images that interact with perception' in Horowitz's (1970) classification (i.e. illusions, perceptual distortions, déjà vu experiences, and after-images) are not classed as mental images according to the description given above. However, phenomena such as hallucinations, dreams and hypnagogic images remain within the category (despite in many cases lacking intentionality) as they are not constrained by sensory interpretation.

For some theorists the elimination of these experiences as mental images may seem inappropriate. After-images, for example, have occupied a primary position in the research into mental imagery. For example A. Richardson (1969) devotes an entire chapter to them in his review of mental imagery. However, if the study of mental imagery is to progress then a clear definition is required and this inevitably entails a strict differentiation between mental images and percepts rather than a blurring of the distinction.

This definition of mental imagery has important advantages to the study of mental imagery and creativity. The eliminated categories of experience have the same properties attributed to percepts and it is therefore an advantage both empirically and theoretically to eliminate them from investigation. A further justification for this decision is that these experiences are rarely linked to creativity. In contrast, those experiences that remain within the definition of mental imagery are frequently associated with creativity.

Conclusion

The aim of this chapter was to provide a definition of mental imagery that would enable progress to be made in future empirical investigation of imagery and creativity. In reviewing the previous work it was found that most definitions use perception as an analogy for mental imagery. However, these approaches do not explain in what particular ways a mental image corresponds to, and can be differentiated from, a percept.

A contrast analysis was used to derive a working definition of mental imagery. Initially it was found that the correspondence between percepts and mental images resides in their shared mode of representation, that is, phenomenologically they are both presented to the individual in an analogical form. What distinguishes percepts from mental images is the function of perception, namely, to derive a meaning from the immediate environment or to pick up information in the environment. Thus, a mental image is an experience that shares the same structural experience as a percept but is not necessarily constrained by its function. It is this characteristic of unconstrained representation that promotes the engagement of mental imagery in creative activities.

The advantage of this definition is that it provides a clear differentiation between mental imagery and perception. This is at the minimal cost of eliminating many experiences that have traditionally been incorporated into the mental imagery framework.

These include: illusions, déjà vu experiences, perceptual distortions, and after-images. The close resemblance of these experiences to perception itself reduces their relevance to the imagery-creativity issue. The author believes that the ground has been cleared of some of its confusing elements. Future research can focus on the most productive line of inquiry - how mental processes can enjoy the benefits of analogical forms of representation while remaining free from the constraints of perception. This, then, defines the role of mental imagery in creativity.

Chapter III

A Classification of Mental Imagery

Introduction

Chapter Two dealt with the problem of the perceptual equivalence hypothesis in the context of the role of mental imagery in creativity. One of the main issues identified was the problem of theory precision noted by Pylyshyn more than twenty-five years ago. An attempt was made to partially rectify this problem through the development of a more precise definition of mental imagery. It was concluded that mental images are experiences that share the same phenomenological nature as percepts but are not constrained by the function of interpretation or acting upon a proximal stimulus.

The aim of the present chapter is to provide an overview of a wide range of mental images and to develop a classification system in which these images can be understood. The classification system is based upon the definition presented in Chapter Two. This categorization is important because it provides the basis for new empirical research and ultimately decides how mental images are to be understood and investigated in the creative process.

The Utility of Classification Systems

Psychology prospers through classification. Structure acts as a foundation for investigation and all future research is understood in its context. It enables progression and the development of coherent information gathering and exchange (Foss, 1995). During the resurgence of interest in mental imagery in the 1960s several attempts were made to develop a system for understanding the various types of mental imagery. However, since the mid 1970s research has virtually ignored the many different types of mental images. Consequently, mental images have become understood in the context of a few experimental protocols; a review of mental imagery in any general textbook in cognitive psychology testifies to this (Eysenck and Keane, 1997; Reed, 1992; Solso, 1991).

Alternative areas of mental imagery have been studied and in many instances they have developed into fields in their own right, but the findings have not been reported as part of the mental imagery literature. Put simply, the parts that make up the area have not been brought together to form a general body of knowledge from which mental images, and their characteristics, can be suitably assessed. This situation causes difficulties in

trying to construct a classification of mental imagery and its role in the creative process. Normally, the task would require a general review of the research conducted in the subject area. However, in the present circumstances it entails the updating of programmes developed more than twenty-five years ago (Horowitz, 1970; McKellar, 1957, 1972; A. Richardson, 1969).

Previous Classification Systems

The most thorough reviews of mental imagery experience have been undertaken by Horowitz (1970), McKellar (1957, 1972), and A. Richardson (1969). All of them offer a broad set of experiences that together form a body of occurrences labeled as mental images. The review from Morris and Hampson (1983) defines the research field from the perspective of cognitive psychology. The approaches reviewed in the present section are those provided by Horowitz and Morris and Hampson. Horowitz (1970) classifies mental images according to four mutually inclusive categories: vividness, context, interaction with perception, and content. Morris and Hampson (1983) list the most well known forms of mental imagery and define these on three dimensions: intentional/passive; intrapsychic/extrapsychic; and real/not real. Although the classifications provided by these two sources highlight the multifarious nature of mental imagery neither fulfills the aims set out in the previous section.

Horowitz's review represents the most thorough attempt to detail all the forms of mental imagery. He does not attempt to distinguish the forms of mental imagery because of the problem arising from the development of mutually inclusive sub-ordinate categories. As he states:

"Because an image experience can be described from so many perspectives, it is often confusing to try to give it one general label. For example, a vivid image of one's body while falling asleep can be called hypnopompic because it occurs in the context of falling asleep, pseudohallucinatory because it is very vivid, or autoscopic because the contents are of the physical self." (Horowitz, 1970, p.6).

Consequently, Horowitz provides a set of categories through which mental images can be described rather than grouped. This is a useful enterprise for his purpose (the use of

mental imagery in clinical research) but it is not sufficient for the present classification procedure.

Aside from the issue of exclusivity there are several problems with using Horowitz's classification in the thesis. The definition given in Chapter Two means that many of the mental images classified by Horowitz are no longer relevant. This is particularly true of Horowitz's third category, "Images which interact with perception". Furthermore, as the aim of the thesis (to investigate the role of mental imagery in creativity) embodies a small element of the total research into mental imagery there are few references to it in Horowitz's review.

The second classification system selected here was developed by Morris and Hampson (1983). They distinguished and defined a selection of mental images on the basis of three dimensions. Justification for these dimensions is based upon the notion that they provide a useful distinction. As Morris and Hampson state:

"Among the dimensions upon which mental images differ are three which help to clarify the common distinctions between types of imagery. These three dimensions are, firstly, the intentional/passive role of the individual in the creation of the image, secondly, the experience of the image as being out there as part of the real world, or as existing "internally" in a different form from real objects, and thirdly, the belief that what is being experienced is part of the real world, or is created in some way by the individual's mental apparatus." (1983, p. 65).

Morris and Hampson's attempt to differentiate mental images seems to have located dimensions that 'carve-the-joints'. As with Horowitz's classification there are many useful aspects of the Morris and Hampson categorization. The three dimensions adopted by Morris and Hampson provide much insight into the different experiences of imaging. However, Morris and Hampson's classification is not suitable for the present thesis because they only list six broad categories of mental imagery.

Table 3.1. Discrete Category Members of the Super-Ordinate Attribute, Visual Mental Imagery

Primary Feature	Secondary Feature	Types of Mental Image
Dream Associated	Somnambulistic	Dream Images
		Hypnagogic Images
		Hypnopompic Images
		Sensory Deprivation Images
		Lucid Dream Images
	Not Somnambulistic	Scintillations
		Daydream Images
		Hypnosis Images
		Meditation Images
Wake Associated	'Looking-at'	Flashbacks
		Pseudohallucination Images
		Psychotic Images
		Psychedelic Images
	'Looking for'	Memory Images
		Mental Rehearsal Images
		Questionnaire Study Images
		Experimental (Perceptual Equivalence) Images
		Synaesthesia Images

The Development of a Classification System for Mental Imagery

The first aim in developing a classification system is to determine one or more generic attributes that define all of the members of the category. Obviously, these fundamental attributes are not 'written in stone' but depend upon the conceptual basis from which the area is to be understood (Willingham and Preuss, 1995). Fortunately, the aim of the present thesis, to investigate the role of mental imagery in creativity, does not conflict with a general conceptual basis. Thus, the initial aim of this section is to develop a super-ordinate construct for mental imagery.

The super-ordinate construct which links all the forms of mental imagery was outlined in Chapter Two. It was proposed that mental images can be specifically defined as percept-like experiences that are not constrained by stimulus interpretation or pick-up. According to this account there are numerous expressions of mental imagery. However, there are also a finite set of experiences that are commonly found in the literature and it is the goal of the present chapter to define and categorise these experiences. The following forms of mental imagery (see Table 3.1) have been selected according to four criteria: they are frequently reported; they are often visual; they are frequently researched; and, they may be associated with creativity.

Having developed a super-ordinate construct that identifies the members of the category of visual mental images it is necessary to develop sub-ordinate attributes. In attempting *to carve nature at its joints* it is clear that the term ‘dream-associated’ is frequently used to describe many forms of visual mental imagery (Horowitz, 1970). Conversely, the ‘dream-associated’ characteristic appears to be a very inappropriate form of description for many other forms of visual mental imagery. Thus, it appears that a wake-like/dream-associated distinction could provide a useful sub-classification of visual mental images. As some mental images that are described as ‘dream-associated’ (e.g. hypnosis images, meditation images, and daydream images) do not occur in the sleeping state, it is possible to further sub-divide ‘dream-associated’ mental images into two discrete categories. Those directly associated with sleeping (somnambulistic) and those indirectly associated with sleeping (non-somnambulistic).

If ‘dream-associated’ mental images can be split according to two discrete categories then it should also be possible to do the same for non ‘dream-associated’ mental images. In considering the many types of mental imagery that appear in this form, the clearest way in which they can be distinguished is through an intentionality criterion. This is similar to Morris and Hampson’s intra-psychic/extra-psychic dimension but has borrowed the phenomenological terms ‘Looking for’ and ‘Looking at’ (Ellis, 1995). ‘Looking for’ mental images are best described as experiences that are intentionally produced and have agency. ‘Looking at’ mental images appear to the experiencer without voluntary control and have no agency. This enables the researcher to differentiate the categories. These forms of mental imagery are presented in Table 3.1.

This classification is not perfect as some of the experiences do not sit comfortably in the positions assigned. For example, there are question marks about the nature of the visual mental images experienced during sensory deprivation. Research has demonstrated that reported visual experiences occur very early on in the sensory deprivation period (Zubek, 1969) and short-duration sensory deprivation tasks do not involve very much sleep (Suedfeld, Ballard, Baker-Brown, and Borrie, 1985-86). Furthermore, the psychedelic images (particularly those which are opium-induced) may sometimes be defined as 'dream-associated' (Julien, 1995). However, in all cases it is argued that these are the most representative category assignments for the experiences and that this categorization is robust enough to facilitate a review of the role of mental imagery and creativity. In the following section each member of the categories listed in Table 3.1 will be discussed.

Dream-associated Mental Images Characterized by their Somnambulistic Nature

The forms of mental imagery discussed in this section are defined by their occurrence in the sleeping state. These forms of mental imagery are very vivid and often have a narrative content. Although there are many examples of their role in creativity there has been little empirical research into 'dream-associated' somnambulistic mental images and creative thinking. The forms of mental imagery discussed are: dreaming images, hypnopompic and hypnagogic images; lucid dreaming images; and sensory deprivation images.

Dream Images

Dreams are atypical mental images, they are rivaled only by hallucinations in their vivid and delusional qualities, and have an incomparable narrative content (Seligman and Yellen, 1987). It is therefore hardly surprising that they have procured a special status amongst the world's religions and that psychoanalysts should be so interested in their informational status. However, since the discovery of their association with REM-sleep the nature of dreaming has been drawn into the realms of scientific inquiry (Aserinski & Kleitman, 1953). There have been many laboratory studies of REM-sleep and much is known about the physiological correlates of dreaming (Empson, 1994). For example, it is now known that the vast majority of people experience dreams during REM sleep and that

dreams occur in adults between three and five times every night and that the high level visual areas in the brain are activated during sleep (Hobson, 1988). It is also established that the occurrence of REM-sleep is associated with brain stem activation and that dreams are accompanied by Pons-Geniculate-Occipital (PGO) waves of cortical activity (Hobson, 1988).

Hobson and McCarley (1977; Hobson, 1988) have used the available physiological information to develop a model of the dreaming brain based primarily upon the known areas of activation during REM-sleep, namely, the higher level sensory and association cortical regions. Hobson and McCarley hypothesize that two groups of neuronal populations in the brain stem (the aminergic neurons and the reticular neurons) act as an on-off switch. Together they determine whether activation occurs in the brain. Hobson (1988) speculates that the aminergic neurons act as the 'on switch' and the reticular neurons act as the 'off switch'. When one of these populations of neurons is active then the other is inhibited.

During the dreaming phase a sensory-input blockade is achieved through the active inhibition of the peripheral central nervous system and occlusion of higher level sensory and associative regions of the brain (Hobson, 1988). These factors produce the characteristics of dreaming. This is accompanied by a motor-output blockade (in the brain stem and spinal cord) which stops the dreamer from carrying out the dream.

Hobson (1988) has also identified five factors that characterize the dreaming state. These are: hallucination; delusion; disorientation; intensification of emotion; and amnesia. The hallucinatory aspect of dreaming is caused by the activation of sensori-motor brain circuits. Hobson claims that:

"If the higher-level neurons of the visual system are subjected to the same type of phasic excitatory signal that they "see" during the waking state, they will process that signal as if it came from the outside world."
(Hobson, 1988, p.210).

The delusional qualities of dreaming are hypothesized to be a consequence of the brain's inability to find an orientational referent from the internal signals generated; without external cues to act as a referent the brain is dependent upon internal sources. Disorientation is caused by the use of a different information processing mode and the multi-sensory array of information processed. The intensity of emotions occurs because of

signal activation in the limbic system and is predominantly anxiety related (Hobson, 1998; Revonsuo, 1998). Finally, it is claimed that the amnesic nature of dreaming results from a failure to activate a record mode during the dream state.

Recent research into dreaming has generally supported and added to Hobson and McCarley's activation-synthesis hypothesis. The trend is toward a model of the dreaming brain as a self-organizing system with unique phenomenological characteristics. For example, brain imaging PET studies have found a reduction in pre-frontal cortical activation during dreaming (as compared to waking). As this area is supposed to be involved in planning, logic and volitional processes during waking it is hypothesized that these processes are reduced during dreaming (Hobson, 1998).

Working in the best traditions of the identity approach this research is building a picture of the dreaming brain that correlates with the phenomenological experience of dreaming. One recent approach (Combs, Kahn and Krippner, 1998) has even attempted to reconcile the differences between the neuroscientific approach and psychodynamic models of dreaming. Using the self-organizing principles of attractor systems Combs *et al.*, (1998) argue that the Freudian narratives and symbols are produced from stable attractor pattern organization following the bifurcations caused by cholinergic induced PGO waves.

The only study relating dreaming to creativity was the finding by Austin (1971) that divergent thinkers had a greater recall of dreams than convergent thinkers. Although there has been little empirical research into dreaming and creativity there are numerous reports of the occurrence of creative insights during dreaming. The best known example in the arts is Coleridge's report of waking after an opium induced dream with the composition of his epic poem, *Kubla Khan* complete. In science there are also reports of creativity. Here are several examples cited by Ochse:

"Dreams and hypnagogic states are apparently fertile fields of inspiration for scientists. Cannon and Helmholtz reported having repeated experiences of answers to their problems on waking. On one such occasion Cannon had an idea as to how he might construct a device for automatically recording the clotting of blood. Hirschel 'discovered' the planet Uranus through a dream; Leibnitz dreamt of the basic idea

underlining his conception of a world system; and Niels Bohr dreamt of his atom model." (1990, p.196).

In summary, a considerable amount of research into the psychophysical correlates of dreams has resulted in a dynamic model of the dreaming brain in which it is hypothesized that activation and inhibition are governed by competing neuronal populations (Hobson, 1998). Because the dreaming state does not lend itself easily to empirical research there have been few studies that have shown a role for dreaming in creativity. However, there are many anecdotal reports which suggest that dream images provide a rich source for creative ideas.

Hypnagogic & Hypnopompic Images.

Hypnagogic images are characterized by their appearance just before sleep and hypnopompic images by their occurrence immediately after sleep. Most researchers treat the two types of experiences as identical, differentiating them only on the basis of the context in which they occur. The term hypnagogic was first applied by Maury in 1848 (J.T.E.Richardson & Mavromatis, 1985). The hypnopompic stage was later distinguished from the hypnagogic state by Myers in 1903.

Early research into the incidence of hypnagogic imagery by Muller in 1848 (cited in McKellar, 1957) suggested that it was a rare phenomenon; only 12% of those surveyed claimed to have experienced hypnagogic imagery. However, later studies have found that a large number of people report the experience. For example, a study by A.Richardson, Mavromatis, Mindel, and Owens (1981) found that 75% of those sampled reported hypnagogic images in the past. Demographic research shows a greater preponderance of hypnagogic images in females (McKellar, 1977) and children (Kanner, cited in A.Richardson, 1969).

The association between hypnagogic and hypnopompic images and self-reported historical creativity is strong. The best known example, Kekulé's use of mental imagery in the creative process, has already been described in the first chapter of the dissertation. Another well known example is provided by Poincaré. As he states:

"Often this feeling [of illumination] deceives us without being any the less vivid, and we only find out when we seek to put on foot the demonstration. I have especially noticed this fact in regard to ideas

coming to me in bed while in a hypnagogic state." (Poincaré cited in Ochse, 1990, p.253).

Several researchers provide reviews of the use of hypnagogic imagery in historical creativity (Ahsen, 1988, 1992; Mavromatis, 1987; McKellar, 1957, 1995). Those individuals who have reported insightful ideas during the hypnagogic stage include: scientists (Edison and Faraday), writers and film-makers (Cocteau, Coleridge, Dickens, Goethe, Keats, Nietzsche, and Wordsworth), composers (Brahms, Puccini, and Wagner) and the Surrealists (Breton, Dali, and Ernst)

Empirical research into hypnagogia and creativity is hindered by the failure to develop operational measures of both hypnagogic and hypnopompic images. This is unfortunate as the anecdotal reports suggest that both hypnagogic and hypnopompic images could offer a fruitful line of investigation. However, it is not surprising given the problems concerning the operationalisation of the variables.

Sensory Deprivation Images

The study of sensory deprivation was initiated at the McGill laboratories in the early 1950s (Suedfeld, 1969a). The early research provoked much interest because of the reports of hallucinations (Zuckerman, 1969). Although it was suggested that perceptual isolation produced a 'model psychosis' later investigation has questioned the validity of the initial conclusions (Reed, 1979). Zuckerman's (1969) review of mental images produced during sensory deprivation found that: visual mental imagery is enhanced; reported visual sensations are most frequently found during the first hour of sensory deprivation; and that, the mental images produced bore a closer resemblance to non-pathological images than to psychotic ones. While some studies dispute Zuckerman's conclusions (Suedfeld *et al.*, 1985-86) the general findings tend to support him (Forgays and Forgays, 1992).

While participants using short-term sensory deprivation techniques claim that it improves creativity (Suedfeld, Metcalfe, and Bluck, 1987) no outstanding creative acts have arisen from the procedure. However, the conditions provided during short-term sensory deprivation (Restricted Environmental Stimulation Technique) suggest that this technique could be employed to investigate the role of mental imagery in creativity. This assumption is based upon converging lines of evidence that suggest that mental images

compete with percepts for appearance in consciousness (Antonietti and Columbo, 1997; Craver-Lemley and Reeves, 1992; Singer, 1966; and, Zuckerman, 1969). Furthermore, it is possible to provide participants with test materials in these environments. Thus, short-term sensory deprivation provides a useful technique for investigating the mediating effect of perceptual competition in the role of mental imagery in creativity. Further information is provided in Chapter Ten.

Lucid Dreaming Images

Lucid dreaming is the experience of being aware of dreaming. A large proportion of people claim to have had lucid dreams (50%, Blackmore, 1991) and researchers claim that people can learn to lucid dream using very simple techniques (LaBerge, 1985). Furthermore, Green and McCreery (1994) suggest that awareness of lucid dreaming is often sufficient to produce lucid dreams. While the contents of lucid dreams are very similar to ordinary dreams (Gackenbach, 1988) there are many differences between the two states. Green and McCreery (1994) outline four major abilities which distinguish the lucid dream from the non-lucid dream: control, reflectiveness, imagination, and memorability. Furthermore, research into the subjective reports of ordinary, vivid, and lucid dreaming suggest that lucid dreams have a greater visual, auditory, and kinesthetic content (Gackenbach and Shillig, 1983). It has also been observed that lucid dream frequency is correlated with dream recall frequency (Gackenbach, 1988) and that more females volunteer themselves as lucid dreamers than males (Wolpin, Marston, Randolph, and Clothier, 1992).

The central question in lucid dreaming is, do these dreams occur during REM sleep? The differences between lucid and non-lucid dreams led early researchers (Hartmann, 1975) to conclude that they must occur outside of REM sleep. It seemed logical to assume that the qualities of lucid dreaming were too similar to an ordinary waking state to predict a REM model (LaBerge, 1985). The main problem for those lucid dream researchers who believed that it appeared during REM sleep was the sleep paralysis that appeared during this period. This was circumvented by Hearne in 1978 when he exploited the fact that eye muscles are not paralyzed in REM sleep (Green & McCreery, 1994). Hearne's discovery of REM based lucid dreaming was further supported by

concurrent research carried out by LaBerge and colleagues (LaBerge, Nagel, Dement and Zarcone, 1981).

Lucid dreaming has developed into a burgeoning industry in the past decade (LaBerge, 1998) with workshop sessions included at conferences (e.g. Tuscon, 1998) and Internet pages offering devices to assist the lucid dreamer in their so called 'self-healing' process (Holzinger, Bolitschek; Saletu, Schmeiser-Rieder, Popovic, and Zeitlhofer, 1998). As part of the New Age market, it is hardly surprising that claims should be made about improvements in creative thinking during lucid dreaming. However, although several studies have found a positive association between lucid dreaming frequency and creativity, the results are inconsistent (LaBerge and Gackenbach, 1986).

'Dream-associated' Mental Images Characterised by their non-Somnambulistic Nature

The following forms of mental imagery occur in a waking state but have a 'dream-associated' quality. These mental images tend to occur in undirected thinking states which have been variously defined as altered states of consciousness (Hilgard, 1992; Naranjo, 1972/1990). There are many examples of the use of mental imagery in historical creativity. There have also been several attempts to empirically validate the association between the variables. The forms discussed in the present section emerge from: dream scintillations, daydreaming, hypnosis, and meditation.

Dream Scintillation Images

The term 'dream scintillation' was first used by Forbes (1949, cited in McKellar, 1972) to describe mental images that were similar to those found in hypnagogic states but occurred during waking (McKellar, 1972). Some people report having dream scintillations after exercise precipitating a fatigued state. Retrospective reports of dream scintillations suggest that they appear passively to the imager. They are intrapsychic (Saul, cited in Horowitz, 1970) and they are not considered to be real by the person having them. There have been no studies reporting a link between dream scintillations and creativity.

Daydream Images

Daydreaming forms a primary part of those mental states classified by Aristotle as undirected thoughts (Gilhooly, 1990). Undirected thinking is characterized by apparently

free flowing ideas emerging into consciousness. These ideas appear involuntarily and frequently take on the form of vivid visual images. In a recent study of situations in which mental imagery occurs Antonietti and Columbo (1997) found that daydreaming represented the most likely situation in which mental images were reported.

Interest in daydreaming resulted from the work of Singer and McCraven in the 1960s. Their study in 1961 found that 96 percent of their sample reported having daydreams every day. These daydreams took the form of clear visual images of people, objects, and events. Other studies have found that daydreaming: occurs at 90 minute cycles throughout the day (Kripke and Sonnenschein, 1978); is related to anticipating and planning future events; and competes with external task demands (directed thinking) for appearance in consciousness (Singer and Antrobus, 1972).

One area of research that highlights Singer's (1975) model of competing internal and external sources is childhood daydreaming. The development of imagination in children encompasses a wide range of creative forms of musing. In a recent review of over sixty reports of 'paracosms' (imaginary private worlds) Cohen and MacKeith (1991) provide a descriptive classification of the many ways in which a child's imagination evolves. The imaginations defined are listed in Table 3.2. Paracosms provide a particularly rich source of creativity in the field of literature. Cohen and MacKeith (1991) list many historically creative individuals whose work reflects the evolution of complex and creative imaginary worlds (e.g. Tolkein, Borges, Castenada, Lessing, Charlotte, Anne, and Emily Bronte, and Asimov). Undoubtedly, the complex world of paracosms provides a rich source of information for novelists of this genre.

The disorganized and fragmented nature of daydreaming has led to much speculation about its role in creativity (Singer and Antrobus, 1972). However, there are few direct referents to daydreaming in the literature on creativity; even Kekulé's omnibus report is better explained as a hypnagogic experience. Nevertheless much can be surmised from the "bath-bed-bus" creativity syndrome (Boden, 1990). Empirical research into daydreaming frequency and divergent thinking has shown a relationship between the two variables in specific environments (Tushup and Zuckerman, 1977).

Table 3.2. Cohen and MacKeith's (1991) Classification of Children's Imaginings

Imaginings	Forms
Simple Creative Behaviours	Transmutory
	Animistic
	Inventing people
	i. Imaginary conversations
	ii. Imaginary companions
Personally Acting a Part	Being a machine
	Being a [non-human] living thing
	Being another [and particular] person
	Enacting an incident
Imagined Participation in the Action of Stories of Others	Hearing a story
	Reading a story [to oneself]
	Producing a play with a standard plot
Invented Stories	Free-floating daydreams
	Pre-sleep serial stories
	Daytime structured short stories and dramas
	Paracosms

Hypnosis Images

Hypnosis has the most colourful and obscure history in which the phenomena alternately mimic epilepsy, hysteria, and analgesia. From Mesmer's 'animal magnetism' to Puységur's 'artificial somnambulism' two themes emerge. The first of these, hypnotic therapy, evolved from Charcot's work on hysteria in the nineteenth Century. The second, hypnotic anaesthesia, arose from the surgical procedures practised by Elliotson, Braid, and Esdaile during the same period (Rowley, 1986). In the twentieth Century hypnosis was finally picked up by psychologists interested in explaining it, as opposed to applying it.

The contemporary debate in experimental hypnosis concerns its position as a state of consciousness. Although there are variations on the general method used to investigate whether hypnosis produces an altered state of consciousness the standard experimental protocol compares the behaviour and reports of so-called 'reals' and 'simulators'. The

‘reals’ are selected from a population of high susceptible participants and the ‘simulators’ from a population of low susceptible participants (based upon a hypnosis scale). The alternative procedure is to use verificational procedures, such as conformity to age-related behaviour during age regression experiments (Wagstaff, 1981). The main experiences and behaviours investigated are: age regression, amnesia, analgesia, and trance logic. Each is briefly discussed below.

The wilder claims of former life regressions (e.g. the Bridey Murphy case) and deep trance infant regressions yielding age-specific Babinski reflexes are rejected by social state (Wagstaff, 1981) and special state theorists (Hilgard, 1977). Less dramatic claims of the reinstatement of certain age-specific abilities during hypnosis, such as Piagetian stages (Reiff and Sheerer, 1959) or the ability to use eidetic imagery (Walker, Garratt, and Wallace, 1976) have been challenged on methodological grounds (Hilgard, 1977; Spanos, 1986). In summary, research into age regression has failed to support the special state hypothesis.

Amnesia is one of the most popularised phenomenon reported in hypnosis. The general experience is a post-hypnotic amnesia for events occurring during the hypnotic procedure. Research into spontaneous amnesia has found discrepancies between ‘reals’ and ‘simulators’ with the latter over-exaggerating the frequency of the phenomenon (London cited in Wagstaff, 1981). However, spontaneous amnesia is not regarded as an appropriate area of investigation (Spanos, 1986). Kihlstrom (1985) claims that differences between ‘reals’ and ‘simulators’ have been found in a wide range of amnesia studies including: source amnesia, disorganised recall, and recognition ability. This claim has been challenged on individual differences and methodological grounds (Coe, 1989; Spanos, 1986).

Anaesthesia is the most spectacular phenomenon to arise from hypnosis and studies of the use of hypnosis as a form of pain relief (the hidden observer effect) formed the basis for the best known theory of hypnosis, namely, Hilgard’s neodissociation model of hypnosis (Hilgard, 1973, 1977, 1992). Hilgard’s (1973) fundamental observation was that during pain studies (e.g. those using a cold-pressor test) participants were able to report a hidden pain dissociated (or at least in the third person) from conscious awareness. Several researchers have noted the problems with hidden observer studies. Of particular note are issues concerning: instruction expectancy effects (Spanos, 1983, 1986), the

deployment of cognitive coping strategies (Spanos, Ollerhead, and Gwynn, 1986), compliance (Spanos, Perlini, Patrick, Bell, and Gwynn, 1990) and positive and negative pre-task expectations (Spanos, 1986).

The concept of trance logic was first noted by Orne (1959). He found that hypnotic susceptible individuals exhibited logically incongruent behaviour and reports during hypnosis. He concluded that there are critical differences between hypnosis and sham behaviour. Orne (1959) identified two particular forms of trance logic that distinguished 'reals' from 'simulators', namely, double hallucination and transparency reports. Several problems have been found in the study of double hallucinations and the empirical research does not altogether support his claim for trance logic (Johnson, Maher, and Barber, 1972; Sheehan, Obstoj, and McConkey, 1976). However, Marks, Baird and McKellar (1986) used a matched controlled design in which 'reals' and 'simulators' were both highly hypnotically susceptible. This study observed both double hallucination and transparency effects in the 'reals' but not the 'simulators'. Also, research into transparency effects has shown that 'reals' consistently exhibit more forms of transparency than 'simulators'. Even Spanos (1986) accepted this but he explains it through artifacts (e.g. differential task demands and individual differences in imagery ability).

The issue concerning the status of the hypnotic experience has important ramifications for the present classification system. While it remains unresolved hypnotic images will continue to be classified as '*dream-associated*' experiences occurring in a non-somnambulistic state. Whatever the resolution, mental imagery has a strong association with hypnosis. It is an important feature of the hypnotic state and most hypnotic scales include a measure of self-reported mental imagery (e.g. the Stanford Hypnotic Susceptibility Scale, Weitzenhoffer and Hilgard 1959). Consequently, many studies have found that high susceptibility to hypnosis correlates with high self-reported mental imagery (Bowers, 1978; Crawford, 1982; Hilgard, 1979; Sutcliffe, Perry, and Sheehan, 1979). Research has also found that performance differences on cognitive and perceptual tasks in high and low hypnotically susceptible participants can be partially explained through imagery ability (Bowers, 1978; Crawford, 1982; Glisky, Tataryn, and Kihlstrom, 1995; Wallace, 1990; Wallace, Allen and Weber, 1994).

Aside from Rachmaninov's use of hypnosis to cure his depression (Rowley, 1986), there is no association between historical creativity and hypnosis. There are a few theoretical and empirical reports of the use of hypnosis in the creative process (Bowers, 1978; Suler, 1980). Bowers measured several factors associated with hypnotizability and assessed these in the context of divergent thinking. She concluded that the most important determinant in the relationship between hypnotizability and divergent thinking performance was effortless experiencing. She also claimed that effortless experiencing accounted for the relationship between self-reported mental imagery and divergent thinking. Bowers' (1978) research provides a useful source of information about the association between imagery, hypnosis, and creativity.

Meditation Images

Meditation sits comfortably below the section on hypnosis. The experiences reported during meditation are very similar to those found in hypnosis (e.g. enhanced mental imagery, hallucinations, free floating fantasy, a regression to unconscious processing, and effortless experiencing). Likewise, both areas are associated with the psychoanalytic concepts of primary and secondary thinking and the inevitable link between primary process thinking and creativity (Suler, 1980).

There are numerous methods used to achieve a meditative state. The two best known forms are Transcendental Meditation and Zen meditation. The former uses a mantra (e.g. chanting 'rama') to invoke a meditative state and the latter uses a koan (e.g. 'what did my face look like before I was born?'). Other meditative techniques employ: visual and tactile focusing (e.g. watching a candle, or constantly touching an object); breathing exercises (e.g. controlled counting). focusing upon an idea (Christian meditation); movement techniques (e.g. gritting teeth, or stomach movements); sitting quietly; and mindfulness.

Given the array of meditation techniques how can a single definition be arrived at? While there appears to be a clear distinction between several forms of meditation (ideational/non-ideational thinking; constricted/dilated perceptual focusing) Naranjo (1972/1990) claims that all forms have the same path and goal. The path is to achieve a 'concentrated state' and the goal is to reach a 'special state of mind'.

Some psychodynamic models of meditation explain the effects in terms of a right-hemisphere primary process phase (Davidson, 1976). The right hemisphere model is appealing because there is some evidence that it plays an important role in the synthesis of emotions and spatio-visual tasks (Fenwick, 1990). Furthermore, increased right hemisphere activity has been found in meditation studies (Fenwick, 1990). However, Fromm (1981; cited in Fenwick, 1990) argues that primary process thinking occurs only in the early stages of meditation. A further feature of the psychoanalytic approach is a clear distinction between meditation and the ego-driven normal state of consciousness.

Self-reports of negative sensations and thoughts during meditation (which often lead to a sense of well being) have led cognitive-behavioural theorists to posit a systematic desensitization hypothesis (Delmonte, 1990). It is proposed that meditation is superior to other relaxation methods because it produces decrements in somatic arousal and allows a reciprocal inhibition of the stimuli through the use of imagery techniques. Thus, meditation allows the user to develop a comfortable therapeutic process in which they can set an agenda. The main problem with this approach is that recent reviews of 'experimental-control' studies suggest that meditation does not reduce arousal levels more than ordinary relaxation (Holmes, 1984, 1990). However, these findings have been challenged on methodological and interpretational grounds (Shapiro, 1985, West, 1985, 1990).

The relationship between meditation and creative thinking was popularized through the work of the Maharshi Mahesh Yogi and others in the 1960s. Ochse (1990) connects some of the strange behaviours of creative people to the use of meditation:

"Several tales told about the extraordinary habits of famous creators reveal that some of them did regularly use techniques somewhat like those mentioned above [meditative focusing tasks]. For example, Kant would stare fixedly through his window at a tower in the distance. Schiller liked to have the smell of rotten apples on his desk while he was writing poetry." (1990, p. 230).

Although there have been few reports of the use of actual meditation in historical creativity an association can be indirectly made through the phenomenologically similar experiences reported during hypnagogia. Mavromatis (1987) in a review of the

relationship between meditative and hypnagogic experiences argues that they share the same cognitive and perceptual disruptions.

Non Dream-associated Mental Images Characterised by their ‘looking-at’ phenomenology

The mental images described in the previous sections were characterized by their ‘dream-associated’ appearance. As was noted in Chapter Two these forms of mental imagery are rarely included reviews of mental imagery in cognitive psychology (e.g. Eysenck and Keane, 1997; Reed, 1991; and, Solso, 1991). These texts follow the standard experimental literature (Finke, 1989; Kosslyn, 1980, 1994; and, J.T.E. Richardson, 1999) in focusing upon non ‘dream-associated’ mental images. However, the non ‘dream-associated’ images discussed in the following section are also rarely discussed in the experimental literature. These forms of mental imagery are characterized by their ‘looking at’ status. That is, the sense of neither controlling nor owning the mental image. The first two areas discussed (flashbacks and pseudohallucinations) have not been associated with creativity. The second two areas (psychotic and psychedelic images) have been linked with historical creativity.

Flashback Images

The term flashback is used to refer to mental images that have been re-formed some time after the drugs effects have worn off. Since the 1960s information has been accumulated about the effects of hallucinogenic drugs on later psychotic episodes. It is estimated that up to 15% of regular users of LSD experience persistent flashbacks. These toxic reactions following hallucinogen use tend to occur in those with pre-disposed psychotic personality disorder (Smith and Seymour, 1994; Vardy and Kay, 1995).

The term flashback has also been used to explain the re-experiencing of mental images during post-traumatic stress disorder. It is unlikely that the experiences formed as a consequence of the use of psychedelic drugs are the same as those experienced as a response to post-traumatic stress disorder. The most obvious difference is the emotional context underlying the two types of flashbacks. Other ways in which they differ might concern the persistence of the flashback after the initial experience, the direct antecedents to the flashback, and the physiological correlates of the flashback. The reason they are

known collectively is because they are both examples of mental images recalled from specific past experiences. Flashbacks are produced involuntarily by the individual. They appear extra-psychically but are not perceived as real by the imager. There is no reported relationship between flashbacks and creativity.

Pseudohallucination Images

The distinction between pseudohallucinations and hallucinations is determined by the experiencer's belief about the source of the image. The term is useful to the extent that many people experience images that have a 'looking-at' quality but are known by the individual not to be real. In the general population the occurrence of pseudohallucinations has been associated with periods of isolation and monotonous sensory stimulation (e.g. long-distance driving and single-handed sailing; Whitlock, 1987). A further condition in which pseudohallucinations occur is immediately after the loss of someone.

In the past decade there has been a resurgence of interest in a condition first reported by Charles Bonnet in 1769 (cited in Shultz and Melzack, 1991). This condition, the Charles Bonnet Syndrome, is characterized by a preponderance of visual pseudohallucinations. It is normally found in older people and is associated with concomitant visual impairments. A description of the pseudohallucinations experienced in Charles Bonnet syndrome is provided below:

"...Monsieur Lullin, at the age of 89 (eleven years after cataract surgery), began to see astonishing images of men, women, carriages, and buildings. The figures appeared in movement: approaching, receding, becoming larger or smaller, disappearing then reappearing. Buildings would rise in front of his eyes, showing their exterior construction. Tapestries in his apartment would change and become those of a "richer taste". At other times the tapestries would be covered in paintings of scenic views. These visual images appeared with his full knowledge that they were not actually physically present." (Shultz and Melzack, 1991, p. 809-810).

There have not been any reports of the use of pseudohallucinations in creativity. It could be surmised that the close relationship between these images and perception offers a

logical reason as to why they are not linked to creativity. As noted in Chapter Two, perception may involve intelligent processing, but it is not creative (Rock, 1983).

Psychotic Images

Reports of auditory and visual hallucinations provide a key diagnostic criterion for a range of psychotic disorders. The basic criterion for a hallucination is the production of an image that has experiential properties normally associated with perception. These are: the appearance of being outside the hallucinator; the ability to be selectively attended to; the property of being able to appear and disappear without the determination of the hallucinator; and the ability to deceive the hallucinator into believing that what they are seeing is real (A. Richardson, 1969). Finally, hallucinations can only be described as such if they occur in a waking state; this excludes dreams, hypnagogic images, and hypnopompic images.

The majority of accounts of hallucinations are reported in those suffering from psychotic disorders. These are normally auditory hallucinations and take the form of audible thoughts; voices arguing; and, voices commenting (Davison & Neale, 1990). Other reports of hallucinations have been related to: the use of hallucinogens (Miller & Gold, 1994; Smith & Seymour, 1994); post-traumatic stress disorder (Davison & Neale, 1990) alcohol withdrawal (Goodwin, 1981); high fever, stroboscopic stimulation, and extreme exhaustion (Rycroft, 1981). These forms of hallucinations are not discussed here.

Studies of the reported incidence of psychotic hallucinations in the general population have been estimated at 10% (Sedgwick, 1894; and Menninger, 1949; both cited in McKellar, 1972). The relationship between hallucinations and other forms of mental imagery has been the subject of interest in recent research (Bentall, 1990). These studies have found that hallucinations are associated with similarly vivid and extra-psychic experiences such as hypnopompic and hypnagogic images (Jakes and Hemsley, 1987) but not with less vivid and intrapsychic experiences occurring during waking states (Chandiramani and Varma, 1987).

In certain conditions psychotic hallucinations have been associated with creativity; particularly those arising from psychedelic experiences (e.g. Coleridge). Recently there has also been a resurgence of interest in creativity and hallucinations originating from an endogenous form. Post (1994), studied the biographies of 291

historically creative individuals and concluded that there were above average rates of psychopathology. While some (Jamison, 1993; Storr, 1972) claim a direct link between creativity and psychopathology (i.e. that madness leads to creativity) the argument is hard to maintain when exogenous predictors (stress induced arousal) of psychotic hallucinations are taken into account (Bentall, 1990). Furthermore, Eysenck (1995) claims that schizophrenics are only capable of creativity when their condition is not exhibited.

Psychedelic Images

The reasons for using psychoactive drugs can be categorized into four groups: ritual/cultural; medicinal/therapeutic; occupational/functional; and, social/recreational (World Drug Report, 1997). While the first category (ritual/cultural) was largely responsible for the introduction of organic psychedelic drugs and the second category (medicinal/therapeutic) for the introduction of synthetic psychedelic drugs the main reason for using psychedelic drugs in the 1990s is for recreational purposes.

There are many drugs that produce psychedelic images. The best known are lysergic acid diethylamide (LSD), mescaline, psilocybin, N,N-dimethyltryptamine (DMT) and 3,4,(±)methylenedioxymethamphetamine (MDMA). Others include myristicine, bufotenine, harmine, hyoscine, and cannabis (Maisto, Galizio and Connors, 1991; Shaw and Crossland, 1981). As LSD, MDMA, and DMT are the most commonly used psychedelics the following section will focus upon these. Although mental images are a central feature of the psychedelic experience there are a range of cognitive and emotional factors that effect the individual. The most notable of these are differences in: time perception, social interaction, defensiveness, emotion, aggression, speech, obsessiveness, restlessness, and impulsivity (Julien, 1995; McDowell and Kleber, 1994; Strassman, 1998).

Psychedelics interact with a range of neurotransmitters but those that effect serotonergic neurons appear to produce the strongest effect (Julien, 1995). It is only recently that the mechanism and site of action has been understood (Aghajanian, 1994). Research has found that hallucinogenic effects are associated with the postsynaptic 5-HT₂ receptors found predominantly in the locus coeruleus and the cerebral cortex.

The best known serotonergic hallucinogen (LSD) was developed by Hofman in 1938. The average dosage required to produce hallucinogenic effects is 0.025 to 0.050

mg. This means that LSD is 200 times more potent than psilocybine and 4,000 times more potent than mescaline. LSD produces very minor physiological effects and the estimated lethal dose is 14mg (280 times greater than the average dose). In the 1960s and 1970s there was a great deal of enthusiasm about the potential of psychedelic drugs to enhance creativity. During this period several studies were conducted into the potential of psychedelic drugs to heighten creativity (Barron, 1969, McKellar, 1957). The results from these studies suggested that the drug could be used to enhance creativity. However, since the 1960s there has been a considerable amount of cynicism about the enhancing abilities of these drugs (Martindale, 1981).

The most commonly used noradrenergic synthetic is Ecstasy (MDMA). MDMA was discovered by the Merck Company in 1914. It was experimented with in the 1950s but only became popular in the 1970s as a psychotherapeutic ‘insight’ drug. Ecstasy remained legal until 1985 when it was classified as a Schedule I drug following a mass advertising campaign in Texas. Ecstasy is the drug of the ‘rave’ culture. There have been no attempts to study the effects of MDMA on creativity.

In the past decade the natural psychoactive preparation, Ayahuasca, has become a popular alternative recreational psychedelic. Ayahuasca is a brown-reddish drink brewed from a mixture of plants found in South America. While these plant extracts contain a range of psychedelic drugs the compound DMT produces the dominant effect. Although DMT has the same molecular interaction as LSD (and produces similar effects) there is no cross-tolerance between the two drugs (Riba and Barbanoj, 1998). As a mixture of many substances the effects of Ayahuasca are less intense than DMT. Like many of these psychedelic drugs Ayahuasca has been associated with ‘insight’ experiences (Shannon, 1998). However, there is no empirical support for this association.

Non Dream-associated Mental Images Characterised by their ‘looking for’ Nature

The forms of mental imagery discussed in the final category of mental images have expansive research literatures. These forms of mental imagery can be broadly classified as ‘cognitive psychology’ mental images. The labels attributed to these mental images are artificial in the sense that they may refer more to the researcher’s aims than to the actual status of the mental image. For example, ‘questionnaire images’ are grouped together because they represent those instruments used by researchers interested in the

phenomenological status of mental images. Similarly, the label ‘experimental images’ refers to a diverse range of mental images that test the perceptual equivalence hypothesis discussed in Chapter Two. As a collective, however, they can all be characterized by their ‘looking at’ status.

As these forms of mental imagery have traditionally been associated with cognitive psychology it is not surprising that the majority of research into the role of mental imagery in creativity has been carried out using these measures of mental imagery. A further reason why they have been used to investigate mental imagery and creativity may be because their non ‘dream-associated’ and ‘looking at’ status makes them amenable to investigation. The two main protocols used to investigate mental imagery and creativity employ the mental images discussed in this section. These are the individual differences approach which uses ‘questionnaire images’ and the image generation approach which uses the emergence properties of some of the ‘experimental images’.

Memory Images

Research into the role of mental imagery in memory has focused upon a variety of factors that influence the individual’s performance on a memory task (Morris and Hampson, 1983). Areas that have been extensively researched include: the imageability of the stimuli; the representation of the stimuli; the strategy for memory; and, individual differences in memory. The subject is so expansive, and the interaction between the areas so complex, that it is not possible to give a full review in the present section. Instead a cursory summary of each area will be provided.

Much memory research has focused upon the nature of the to-be-remembered material (e.g. distinctiveness, meaningfulness, familiarity, word length). Early experimental research found that performance on paired associate tasks was mediated by mental imagery (Paivio, 1963, 1965, 1969, 1971; Paivio and Madigan, 1968; Paivio, Yuille, and Madigan, 1968). Furthermore, later research has shown that imageability is distinguishable from concreteness and that emotionality is independently linked to imageability (Benjafield, 1987; J.T.E. Richardson, 1975, 1999).

The use of imagery instructions to facilitate memory performance has been a subject of interest since Yates’ (1966) examined the method of loci. The most frequently used imagery strategies are the keyword method, the method of loci and the peg-word

mnemonic. In its simplest form the keyword strategy involves the construction of a mental image to accompany the to-be-remembered item. Paivio demonstrated the effectiveness of this strategy in a simple experiment on imagery and pronunciation instructions (see Paivio, 1989). He found that the participants performed twice as effectively when asked to form an image than when asked to pronounce a word. Atkinson (Atkinson, 1975; Atkinson and Raugh, 1975) found that performance in second-language learning was increased when the participants were instructed to image foreign language words with their own language equivalents. In one study they found that participants who used the key-word strategy learned an average of 72% of 120 Russian words compared to a control group that learned only 46% of the words (Atkinson and Raugh, 1975).

The basic strategy employed in the method of loci mnemonic is to place the to-be-remembered items in relation to objects in a room (if a speech is given) or along a particular route. Whilst doing this the person forms an image at each given position and these images and localities then serve as cues for aiding recall. Empirical research into the effectiveness of the method of loci has shown that the mnemonic is most effective when learning oral material (De Beni, Moè, and Cornoldi, 1997). Disruption of the mnemonic, using concurrent visuo-spatial tasks, has been used to support and evaluate Baddeley's concept of a visuo-spatial scratch pad (Baddeley and Lieberman, 1980; Logie, 1986).

The peg-word mnemonic (or 'one bun' mnemonic) is similar to the method of loci. The aim of the peg-word method is to literally 'hang' the to-be-remembered items in a numbered order. As the words are hung they are then imaged with their ordered 'one bun' associates. Baddeley and Lieberman (1980) showed that performance on the method of loci was disrupted more than the peg-word mnemonic when participants performed a concurrent spatial tracking task. Logie (1986) showed that performance on the peg-word mnemonic was similarly affected when the participants' performed a visual matching task. These studies suggest dissociable visual and spatial systems (Logie, 1989; Logie and Marchetti, 1991).

The final area reviewed concerns individual differences in imagery ability (questionnaire studies are discussed in the next section). Studies of eidetic imagery have been reviewed by A. Richardson (1969) and later by Haber (1979). They concluded that eidetic imagers are very rare and that this ability normally disappears in adulthood. Techniques used by people with extra-ordinary memory skills have often been linked to

mental imagery. For example, Luria found that his subject (Shereshveskii) used synaesthesia to enhance his memory abilities (McKellar, 1997).

Research into the clinical use of mental imagery strategies in brain damaged patients has been reviewed by J.T.E. Richardson (1999). Richardson (1999) concluded that mnemonic training procedures following brain damage result in significant improvements in memory. Although initial studies of brain damage focused upon a right-hemisphere hypothesis, research findings since the 1970s have shown that mnemonic techniques improve memory impairments in both left and right hemisphere damaged individuals (Richardson, 1999).

Where attempts have been made to link memory to creativity they have focused on the application of specific problem solving heuristics that may (or may not) facilitate the creative process (Stein, 1989). For example, there has been a lot of research into the successful and unsuccessful transfer of problem solving heuristics (Gick and Holyoak, 1980; Holyoak and Koh, 1987). However, this research has little bearing upon mental imagery. Furthermore, very few imagery researchers proposing a role for mental imagery in creativity note the mediating effects of memory. However, the ability to form mental images from past experience seems essential to the creative process at least in the preparatory stage and in some circumstances (architecture, the arts, or even mathematics) in the actual productive phase (Paivio, 1983).

Paivio (1983) offers several insights into mental image representation and creativity. He argues that the visual code has many advantages over the verbal code (e.g. a greater capacity, economy of organization, stronger accessibility, and better retrieveability). Perhaps his strongest case, however, is the demonstration of the aesthetic appeal of the image and its subsequent adoption by many creative writers and artists. As he states:

“Imagery provides a rich storehouse of concrete memories that constitute our knowledge of the world. It provides an integrated way of organizing such information and ready access to the various components. It is also highly transformable or manipulable with relative freedom from the linear constraints that characterize language. Imagery is therefore the system *par excellence* for creative work, for unconstrained leaps of imagination.” (Paivio, 1989, p.269).

However, Paivio (1983) makes no specific reference to how the experimental protocols adopted in memory research could be used to investigate creativity. Two possible areas of memory research that may show a role for mental imagery in creativity are the imageability and mnemonic studies. Both of these are theoretically dependent upon an associationistic model of creativity (Mednick, 1962). For example, the role of imageability in 'associate' and 'solution' words may be an important predictor of performance in the original remote associates task and the dyad of triad version developed by Bowers, Regehr, Balthazard, and Parker (1990). Conversely, the loose associations produced in some mnemonic strategies may facilitate creativity through the use of 'thought-diversifying strategies' (McGuire, 1997). This research links well with Hargreaves and Bolton's (1972) unexplained finding that divergent thinking abilities correlate with paired-associate learning performance.

Rehearsal Images

A recent body of research has linked mental rehearsal to the activation of the motor system and peripheral regions (Marks and Isaac, 1995). Inevitably, much of the applied research is based on the use of mental imagery in sport (Kremer and Scully, 1994). Consequently, the following review concentrates upon this particular area of mental rehearsal.

Although athletes have employed psychology in sport for a very long time it is only in the past three decades that it has become an integrative part of sports science programmes (Cox, 1994). These programmes have employed cognitive intervention strategies designed specifically to enhance sporting performance. An important element of interest is in techniques designed to enhance motor processes. Mental imagery, as practice and elaboration, sits comfortably alongside goal setting, relaxation training and self-talk as an established form of skills training (Hardy, Jones, and Gould, 1997).

The use of mental rehearsal as an aid to performance enhancement seems to be widespread in elite athletes. A typical mental imagery programme follows a very similar format to a clinical application. One study of the use of mental rehearsal found that 70% of Olympic athletes reported using mental rehearsal (Ungerleider, Golding, Porter, and Foster, 1987). The accumulation of research into mental rehearsal has resulted in an

impressive array of findings. These are summarized by Cox (1994) in her review of mental imagery in sport (see Table 3.3).

Table 3.3. Cox’s 10 Principles Associated with the Application of Mental Imagery to Sport

1. Imagery skills can be developed
2. Effectiveness of imagery is dependent upon a positive attitude towards imagery
3. Advanced athletes benefit the most from using imagery
4. Imagery is more powerful when combined with effective relaxation
5. Imagery can be used in the first person (internal) or the third person (external)
6. Imagery is more potent in performance enhancement in self-reported High Imagers
7. Negative outcome imagery results in greater decrements in achievement than positive outcome imagery
8. Those who use imagery enhance their performance more than those who do not
9. Imagery is widely used by sports people
10. The better a person is at using imagery the more effective is the imagery

There have been no studies of the role of mental imagery in creative sports performance. In assessing a possible relationship between mental rehearsal and creativity two operational problems need to be considered. The first is the problem of defining creativity within sport and the second is the development of tools that adequately measure this creativity. Clearly, it would not be possible to assess the effects of mental rehearsal on creativity using standard divergent thinking tasks. To understand the role of mental rehearsal in creativity it would be necessary to use experts to assess creativity (and skill) following the use of imagery training techniques.

Questionnaire Images

The main philosophical problem with mental images is that they are private experiences that are inaccessible to observation. Conversely the main practical problem with mental images is that they are private experiences that do not produce consistent and replicable findings. Hence, the resurgence of interest in mental imagery research resulted from the development of consistent and interpretable measures of mental imagery in

memory and spatial tasks (Paivio, Yuille and Madigan 1968; Shepard and Metzler, 1971). However, some characteristics of mental imagery are not amenable to behavioural observation and could not be properly represented in behavioural tasks. In these circumstances it is necessary to develop measures of self-reported mental imagery that are consistent and replicable. The most commonly reported characteristics of mental imagery investigated are vividness, control, and preference. Each is briefly discussed below.

As traditional philosophical (e.g. Empiricism) and practical (e.g. memory mnemonics) applications of mental imagery have emphasized the brightness and clarity of mental imagery it is not surprising that the vividness of imagery was the first aspect to be empirically investigated. Galton's interest in visual imagery led to the development of his "Breakfast Table Questionnaire" and was followed by Betts' 150 item questionnaire (The Betts' Questionnaire upon Mental Imagery).

The Betts' QMI remained the standard measure of the vividness of mental imagery until the resurgence of interest in self-report measures of imagery occurred in the 1960s. The first modification of the Betts' QMI was carried out by Sheehan (1967) who produced a shortened 35 item version. Later, Marks (1972) returned to Galton's original emphasis upon visual imagery when he developed the Vividness of Visual Imagery Questionnaire (VVIQ). Marks (1972) produced 16 to-be-imaged items reported in an 'eyes open' and 'eyes closed' format. Marks (1972, 1973) hypothesised that participants with high self-reported vividness of visual imagery would perform better than those with low self-reported vividness of visual imagery on a prompted picture recall task. Since Marks' original study a vast amount of research has been carried out into the relationship between the vividness of visual imagery and cognitive performance. Assessments of the criterion validity of the VVIQ have reviewed over 150 studies (Marks, 1985, 1989, 1995, 1998; McKelvie, 1995). These agree that the VVIQ achieves optimal predictive validity with other self-report measures and shows acceptable criterion validity on cognitive and perceptual tasks (McKelvie, 1995).

The control of mental imagery also formed an important element of Galton's empirical observations and was used by Jaensch as a key factor in his model of personality (A. Richardson, 1969). The best known measure of the control of imagery was developed by Gordon (1949) as a predictor of racial stereotyping (The Gordon Test of Visual Imagery Control: TVIC). She found that people with low control (autonomous

imagers) were more likely to produce racially stereotyped images than those with high control (controlled imagers). Following 15 years of clinical application A. Richardson (1969) produced a modified version of the TVIC that could be used as a continuous variable. As a result the TVIC has become a common adjunct to measures of vividness of mental imagery in self-report studies (McKelvie, 1995).

Given the nature of the TVIC it would be expected that it measures some form of spatial ability and that this would be reflected in tests of association with both spatial ability tasks and mental transformation tasks. However, research has found no association between the TVIC and measures of spatial ability (Di Vesta, Ingersoll, and Sunshine, 1971; Ernest, 1977).

Although there have been no thorough reviews of the functional utility of the TVIC many studies have been carried out into the various forms of reliability and validity. Despite A. Richardson's adjustment of the TVIC scores on this scale are more susceptible to ceiling effects than other self-report measures of imagery (Hiscock, 1978; Kihlstrom, Glisky, Peterson, Harvey, and Rose, 1991; A. Richardson, 1972). Research has shown that the TVIC has acceptable internal reliability and good test-retest reliability (Ashton and White, 1974; White, Sheehan and Ashton, 1976). Factor analyses have shown three or more factors emerging from the 12 item test (Kihlstrom *et al.*, 1991).

There have been several attempts to modify or elaborate upon the TVIC (Ahsen, 1985, 1993; Lane, 1977). Ahsen (1993) developed a parental filter version of the TVIC (AA-TVIC) and Lane (1977) used the format of the Betts' QMI to develop a multi-modal measure of the control of mental imagery. Although Lane (1977) found that the seven modality-specific groupings all loaded on a single factor the other factors were not modality specific.

The notion that individuals have a preference for visual or verbal processing is as old as the concept of vividness (Richardson, 1969) and was investigated by Bartlett (1932) in his 'ways of thinking' studies. In the last three decades several researchers have developed self-report measures of cognitive style. Two of the best known measures of verbal and visual preferences are Paivio's (1971) Individual Differences Questionnaire (IDQ) and A. Richardson's (1977) Verbaliser-Visualiser Questionnaire (VVQ). A brief review of each is given below.

The IDQ consists of 86 items that are roughly split into statements pertaining to verbal thinking (e.g. 'I enjoy doing work that requires the use of words') and visual thinking (e.g. 'I find it easy to visualize the faces of people I know'). The participants are required to answer 'True' or 'False' to the statements and the scores are collated for cognitive preference. The IDQ has been used far less frequently than the self-report measures of vividness and control of visual imagery. Paivio's original study investigated the association between the IDQ and a wide range of imagery and verbal measures. Paivio (1971) found that the imagery component of the IDQ loaded with other self-report measures of imagery (e.g. vividness and control) and that the verbal component loaded with vocabulary tests. Hiscock's (1978) 72 item version of the IDQ showed similar associations. Hiscock (1978) also found that females tended to respond higher on the mental imagery items than males. As this sex difference contradicted the findings from spatial ability studies (Maccoby and Jacklin, 1974) some researchers questioned the validity of self-report measures (Ashton and White 1980). However, later research has shown that self-report scales measure preference for non-spatial mental imagery (Harshman and Paivio, 1987).

A shortened form of the IDQ was developed by A.Richardson (The Verbaliser-Visualizer Questionnaire: VVQ) to study cognitive style and hemispheric asymmetry (A.Richardson, 1977). He found that participants made more leftward eye movements when they were performing the imagery component of the VVQ. However, this finding has not been consistently replicated and it is now accepted that non-spontaneous eye movements do not predict hemispheric processing activity (J.T.E.Richardson, 1999). The VVQ has not fared well in analyses of reliability and validity. In a recent study Antonietti and Giorgtti claimed that, "Most studies have failed to support the notion that the VVQ predicts the actual use of a verbal or visual code in thinking" (1996, p.60).

Questionnaire images hardly resemble the kinds of images reported by historically creative individuals. The key distinction being that the participant is required to construct a fixed image from memory or imagination. However, they may act as a measure of general abilities in image production and they do offer the opportunity of creating alternative questionnaires that may be tailored to those aspects considered important in creativity research.

There have been many studies of the relationship between self-reported mental imagery and divergent thinking (e.g. Bowers, 1978; Campos and Gonzalez, 1993; Forisha, 1981; Khatena, 1975; Parrott and Strongman, 1985; and, Shaw and DeMers, 1986). All of these studies have used an individual differences approach to investigate the role of mental imagery in creativity. In these studies it is hypothesized that those who report mental imagery that is vivid or easy to control will perform better on a divergent thinking task than those who report mental imagery that is non-vivid or difficult to control. A literature review of empirical studies employing self-report measures of mental imagery (see Chapter Four) shows that this is the dominant method used to study the role of mental imagery in divergent thinking performance. The majority of the studies have investigated the association between the vividness and control of mental imagery and performance on Torrance's tests of creative thinking (Torrance, 1974). This area of research requires further examination.

Experimental Images: The Perceptual Equivalence Hypothesis

A criterion for mental imagery discussed in Chapter Two was that an image resembles the qualities of its modality-equivalent percept. Many researchers believe that this basic criterion logically entails a representational equivalence (Block, 1983). That is, that imagery and perception have the same (or equivalent) mechanisms. Consequently, a host of experimental studies have been developed to verify perceptual equivalence. The debate over the representational status of mental images has led to a flurry of experimental protocols that subsume the literature on mental imagery. For example, in a recent literature review (using PsychLit) of one of these experimental protocols (mental rotation) over 100 citations appeared in the past three years.

Studies of the overflow and acuity of mental images have been carried out to assess the perceptual equivalence hypothesis. Kosslyn (1978), measured the angle at which 'overflow' occurred through a 'stop the mental walk' protocol. He concluded that the point of overflow was linearly determined to an object size equivalent to perceptual overflow. However, more recent research has found non-equivalence (Hubbard and Baird, 1988) and explanations for equivalence need to account for evident experimental task demands (Mitchell and Richman, 1980). Acuity studies (i.e. studies that measure the level of resolution of the visual field) have shown equivalent decrements in spatial frequency

resolution tasks (Finke and Kurtzman, 1981). This finding has also been challenged on methodological grounds (Intons-Peterson and White, 1981).

The study of anomalous perceptual experiences in the 1960s were intended to demonstrate that perceptions are often constructed from past experiences (Gregory, 1966). The finding that the perceptual system regularly misinterprets specific forms of sensory information has resulted in similar studies being carried out in mental imagery to test the perceptual equivalence hypothesis. For example, Wallace (1984) found similar size deceptions when the Ponzo illusion was visualised. However, research employing the more complex ambiguous figures tasks (e.g. The Jastrow duck/rabbit figure) by Chambers and Reisberg (1985) does not support an equivalence hypothesis. However, later attempts have succeeded in demonstrating an equivalence for complex tasks when more specific instructions are given to the participants (see Kosslyn, 1994). Finally, recent research has also demonstrated the phi phenomenon effect when imaging (Broscole, Chan, Brandt-Tiven, Miller, and Sanders, 1997).

The mental rotation task was developed by Shepard and Metzler (1971) to test an hypothesised imaginal and physical transformational equivalence. Shepard and Metzler (1971) presented participants with pairs of three-dimensional shapes at different orientations from each other. The aim of the task was to state whether the shapes were identical or a mirror reversal. Shepard and Metzler found an inverse linear relationship between the time taken to perform the task and the angular distance between the shapes. They concluded from these findings that there was a transformational equivalence between imaged and physical rotation.

Since Shepard and Metzler's (1971) demonstration of the mental rotation effect an enormous number of confirmatory findings have been found (Finke, 1989; Kosslyn, 1994). Although alternative accounts have been put forward to explain the effect (e.g. tacit inference, reference frame strategy, and eye-movement) the volume of diverse experimental confirmations and the participants' claims about using mental imagery to perform the task supports the isomorphic transformation equivalence proposed by Shepard (1984). This conclusion is also strongly supported by neuropsychological studies which report increased activation in visuo-spatial regions when participants perform the mental rotation task (Kosslyn, 1994).

With the exception of the mental rotation task Kosslyn's (1973) mental scanning protocol is the most frequently cited mental imagery task. Kosslyn (1973) found that image scanning was governed by the same spatial metric found in perceptual search tasks; that is, an inverse relationship between time and distance. The prototypical mental scanning task was carried out by Kosslyn, Ball, and Reiser (1978) in response to research demonstrating non-spatial effects (Lea, 1975). In this experiment the participants were shown a map of an island and required to memorise it to a level where they could demonstrate a competent knowledge. They were then asked to image a black speck moving at a constant speed between objects located at different places on the island. This experiment showed a near perfect association between the distances between the objects and the time taken to complete the task.

Although the image scanning protocol predicts the same geometric principle underlying Shepard's (Shepard and Metzler, 1971) image rotation experiments there are crucial differences between the tasks. For example, the scanning paradigm requires explicit instruction and a greater reliance upon short-term memory. Furthermore, the scanning task yields a phenomenal (as opposed to a behavioural) measure of imaging ability. Nevertheless, the image scanning protocol has been subjected to the same criticisms as the mental rotation protocol. These include, experimental task demand and expectancy accounts (Intons-Peterson, 1983; Mitchell, and Richman, 1980; Richman, Mitchell, and Reznick, 1979) and cognitive penetrability explanations (Pylyshyn, 1981).

One consequence of these criticisms has been the development of new experimental designs that further support the equivalence hypothesis (Denis and Kosslyn, 1999). For example, Denis and Carfantan (1985, 1986) showed that the participants were not generally aware of the outcome of scanning experiments. Furthermore, Finke and Pinker (1982) designed a scanning protocol which minimised demand characteristics whilst still showing the same spatial metric and Jolicoeur and Kosslyn (1985) showed that experimenter effects did not confound the basic spatial metric.

Having established a robust image scanning effect research has been drawn to understanding the neural correlates of image scanning. Neurological investigations into image scanning have followed from the experimental cognitive research and have generally been used to assess a hypothesised shared image-percept neural substrate. Whilst some research has identified activity in areas used in perception (e.g. occipital,

parietal, and sensori-motor regions) when participants perform an image scanning task the findings are not conclusive (Denis and Kosslyn, 1999).

While there has been a considerable amount of research into self-reported mental imagery and divergent thinking performance the individual differences approach to the study of mental imagery in creativity has not investigated the mental imagery tasks discussed in this section. This is surprising given Shepard's (1978) claim that mental transformation is a key aspect of creativity. However, this may reflect the underlying aim of these experiments which is to demonstrate the existence of a shared form of representation. This is very different from the self-report studies which tend to focus upon the ways in which people differ in the processing of information (Marks, 1972, 1973).

As the objective of the experimental protocols listed in the present section is to show that mental imagery is perceptually equivalent in all individuals it is hardly surprising that investigations of the use of mental imagery in creativity postulate strategies rather than individual differences. In the past decade demonstrations of the use of mental imagery in creativity have used a protocol that requires the generation and synthesis of stimulus parts into creative composite forms (Finke, 1990, 1996; Finke and Slayton, 1988; Finke, Ward, and Smith, 1989, 1992). These methods (referred to in the present thesis as the image generation approach) have found that participants are capable of producing creative responses to tasks which necessarily involve the use of mental imagery. Although these tasks are not representative of the experimental protocols presented in this section they share the same emphases upon the generation, transformation, and interpretation of mental images. The image generation approach is comprehensively reviewed in Chapter Seven.

Synaesthesia

Synaesthesia is defined as the transference of one mode of sensory information to another. This can take the form of a conceptual translation or an image translation. The most commonly cited example of synaesthesia is 'colour hearing'. This is the representation of auditory sensations as both sounds and colours. In some individuals an extremely vivid form of synaesthesia is experienced involuntarily; this may be the case for a large number of individuals during hypnagogic and hypnopompic states (Mavromatis,

1987). Synaesthesia has also been reported following the ingestion of such hallucinogenic compounds as mescaline, marijuana and LSD (McKellar, 1997).

Early twentieth century research reported that between 1-10% of the population claimed to have synaesthesia (Domino, 1989). Later research, however, has shown that approximately 20% of the population report synaesthesia (McKellar, 1997). Unusual synaesthetic images that are immediately identifiable have been linked with eidetic imagery and its consequent memory facilitation; Luria's studies of the journalist Shereshveskii are often cited in this context (McKellar, 1997; Richardson, 1969). McKellar (1997) also reports the use of synaesthesia as a mnemonic in occupations which require a complex form of information storage and retrieval. Ahsen (1997) reports several cases of synaesthesia during phosphene application. McKellar (1997) suggests that synaesthesia may also be used to control pain (visual-analgesic synaesthesia). Furthermore, research into synaesthesia shows that mild sensory transference is common. For example, L.E.Marks (1978,1982) investigated how the sounds of some pseudowords were associated with particular geometrical features. He found that pseudowords like 'maluma' produced round visual representations, whereas others, like 'takete' produced angular representations.

While few people experience the kind of synaesthesia reported by Luria's subject the presentation of synaesthetic material is common. Given the popularity of many synaesthetic presentations (e.g. Walt Disney's *Fantasia*, sound and light shows, and even firework concerts) it would appear that many people enjoy and comprehend the synaesthetic experience. Furthermore, the prevalence of synaesthetic idioms (e.g. the colour-temperature idiom) suggests that they are a useful way of defining emotional relatedness.

Synaesthesia, with or without mental images, appears to be an implicit skill (that can be learned) used for artistic creation. Some art forms (e.g. dance) are based upon the transference of information from one sensory modality to another. The transference from an auditory to a visual mode is quite frequently reported and there are many examples of composers (e.g. Berloiz, Debussy, and Wagner) reporting the experience of synaesthetic images (McKellar, 1997). Similarly, many poets have exploited the aesthetic qualities of synaesthesia. Extracts from Bauderlaire, Shelley, Poe, Rimbaud, Tennyson, and Fitzgerald demonstrate the use of synaesthesia in literature (Marks, 1982; McKellar, 1997). Several

researchers have carried out studies into synaesthesia and creativity (Domino, 1989; L.E.Marks, 1982). For example, Domino (1989) found that those who reported synaesthesia performed significantly better than controls on four measures of creativity.

Conclusion

The aim of the present chapter was to develop a classification system that distinguishes and describes different kinds of mental images. A review of the literature showed that there had been no previous attempts to do this in the context of creativity. It also showed that a general classification of mental imagery had not been attempted for more than decade. Consequently, it was necessary to construct new sub-ordinate categories and to define discrete members of each of these categories. The first distinction between mental images was made on the basis of their association with the dreaming state. This resulted in the selection of nine distinguishable forms of mental imagery associated with the dreaming state and nine forms of mental imagery not associated with the dreaming state. These categories were further broken into two sets and each was individually reviewed in the context of its possible role in creativity.

The findings from the review show that there are many forms of mental imagery that have been associated historically with creativity. These appear in both of the major sub-ordinate categories but are more prevalent in the 'dream-associated' category. However, empirical investigations into the role of mental imagery have concentrated on mental images that are characterised by their non 'dream-associated' status and which have a 'looking at' status. Thus, although the empirical literature seems to be driven by the anecdotal reports of historically creative individuals (e.g. Finke, 1996; Forisha, 1981; Shepard, 1978a) the methods used differ from the historical record most evidently in their use of non 'dream-associated' mental images. Even though this is counteracted by a smaller number of reports of the use of deliberate waking images (see Chapter One) the disparity requires further consideration. Therefore, it will be necessary to address this area at some stage in future investigation. Initially, however, the research needs to closely follow methods where a substantial empirical literature already exists.

Table 3.4. Examples of Historically Creative Individuals Who Have Reported the Use of Mental Imagery in the Creative Process

Area	Creative Individual
Science & Philosophy	Bohr, Cannon, Crick, Edison, Einstein, Faraday, Helmholtz, Hirschel, Kant, Kekulé, Leibnitz, Neitzche, Poincaré, Tesla,
Art, Film & Sculpture	Breton, Cocteau, Dali, Ernst, Hitchcock
Literature	Asimov, Baudelaire, Borges, Castenada, Coleridge, Dickens, Fitzgerald, Göethe, Keats, Lessing, Poe, Rimbaud, Schiller, Shelley, Tennyson, Wordsworth.
Music	Beethoven, Berlioz, Brahms, Debussy, Mozart, Puccini, Wagner

The review of the role of mental imagery in creativity presented in this chapter provides the bedrock for the empirical research presented in the following chapters. As all of the minor categories of mental imagery show some evidence of a role in creativity, it is not possible to select a specific area and state that this is the particular source of creativity. Instead, the empirical investigations that follow must extend and add to the research that has been carried out in the past. The method of investigation that has been most frequently employed in the previous research is the individual differences approach. This method starts from the premise that people differ in their abilities to produce mental images and that these differences have an impact on how creative an individual is. As the previous research has shown that there is a relationship between self-reported mental imagery and divergent thinking performance, further investigation could be made using new methods of inquiry. This research is presented in Chapters Four, Five, and Six.

Although the individual differences approach has been adopted there is no reason why alternative methods cannot be married to this approach. The image generation approach, for example, has shown that people are capable of generating creative responses from imagery-bound tasks (Finke, 1990, Finke, Ward, and Smith, 1992). This method has the advantage of demonstrating a clear link between mental imagery and creativity. However, it has not been demonstrated how individuals differ in their performance on this

task. For example, there have been no attempts to explain the hypothesised roles of image generation, transformation and synthesis in predicting performance on the task. Thus, the individual differences approach could be applied to the image generation approach as a method for further understanding both methods. That is, it may show how imagery abilities determine creativity in an imagery-bound task. This research is presented in Chapters Seven, Eight and Nine.

Finally, the major failing with both of the approaches presented so far is that they have not taken into account the primary source of evidence for the role of mental imagery in creativity. This is that those who have produced historically creative ideas tend to report the use of mental imagery in conditions where internal source demands ('dream-associated' states) dominate external source demands (Singer, 1975). Evidently, further research into the role of mental imagery in creativity needs to be undertaken. One method that may be selected to investigate the role of external source demands in predicting performance on a creativity task is to vary the amount of congruous and incongruous perceptual information (Flowers and Garbing, 1989). The results from this type of research could provide valuable information about the role of mental imagery in creativity, especially if it is investigated from an individual differences perspective. This research is presented in Chapter Ten.

In conclusion, the present chapter has indicated how mental images can be distinguished from each other on the basis of whether they appear to the imager as 'dream-associated' or not. Furthermore, 'dream-associated' mental images can be categorised according to whether they are experienced in a sleeping state or not and non 'dream-associated' mental images can be divided into those which have a 'looking at' status and those which have a 'looking for' status. This classification may not be perfect, but it does provide a basis upon which the various forms of mental imagery can be assessed and evaluated in the context of the creative process.

A review of the literature shows that the majority of anecdotal reports of mental imagery and creativity occur in 'dream-associated' mental states. This is contrasted with the primary experimental methods for investigating the role of mental imagery in creativity (the individual differences approach and the image generation approach) which require participants to create mental images in a fully alert mental state. The conclusion from the present review is that the individual differences approach provides a valuable

source of information about the role of mental imagery in creativity. However, in its present form it may be too narrow to enable a full empirical understanding of mental imagery and creativity. Therefore, the individual differences approach could fruitfully be applied to other empirical methods (the image generation approach) and also to an area where there is a paucity of research into the role of mental imagery and creativity, the interaction of mental imagery, perceptual source demands, and creativity.

Chapter IV

A Meta-Analytic Investigation into the Relationship Between Self-report Measures of Mental Imagery and Performance Measures of Creativity

Introduction

In the review carried out in Chapter Three it was found that empirical investigation into the role of mental imagery in creativity has evolved into two independent protocols. The first of these, the individual differences approach, has focused upon the association between self-reported mental imagery and well established divergent thinking measures. The second, the image generation approach, employs protocols that aim to investigate the use of mental images in creative thinking by the experimental method. Of the two methods used to investigate mental imagery and creativity, the individual differences approach has both the longest history and the greatest reliance upon traditional statistical procedures. Consequently many studies have been carried out using a range of mental imagery and divergent thinking predictors. As these studies normally employ conventional hypothesis testing procedures it is possible to carry out a systematic empirical investigation into the individual differences approach.

Traditionally a review of mental imagery and divergent thinking studies necessitates the selective sampling of empirical and non-empirical evidence relevant to the hypothesis under investigation (Forisha, 1981). This method is useful when the research area is new but when a sufficient number of studies have been conducted the researcher can avoid selectivity in favour of a systematic investigation into the hypothesis of interest. This technique, involving the weighted summation of the results from many research papers, is called a “meta-analysis”. The main advantage with using this approach is that it provides the researcher with a reliable estimate of effect size. Other advantages include the detection of optimal predictors and an assessment of the homogeneity of research findings.

Although meta-analytic reviews provide a unique and powerful source of empirical information, their use is not without controversy. Combining studies can lead to very erroneous conclusions if the selection procedures are not thoroughly considered. For example, selecting research papers on a broad *ad hoc* basis can lead to what Glass (1978) refers to as ‘counting apples and oranges’. Other problems concern an inevitable ‘loss of information’, distinguishing ‘good’ from ‘bad’ studies and the general masking of contradictory information (Rosenthal, 1991). These problems cannot be avoided but their impact can be limited by the use of carefully chosen selection criteria.

In summary, mental imagery and creativity have traditionally been investigated from an individual differences approach. The advantage with this method is that enables the researcher to empirically test a hypothesis according to the conventional hypothetico-deductive testing procedures. However, when a sufficient number of studies have been carried out alternative methods can be used to evaluate specific effect sizes. As a large number of studies into the relationship between mental imagery and creativity have been carried out the aim of the present chapter is to undertake a meta-analytic review of their research findings.

The Relationship Between Anecdotal Evidence and Empirical Research

It is evident from the previous chapters that the stimulus for empirical research into the role of mental imagery in creativity is the anecdotal literature on the use of mental imagery in historical creativity. However, although many researchers acknowledge the different forms of mental imagery implicated in the creative process (e.g. Forisha, 1978) their research does not reflect the variability of imagery contexts. Instead research focuses upon mental images that are generated in the waking state and which have a 'looking-for' status; in the sense that they are generated and introspected upon. Prior to evaluating these studies it is interesting to assess the types of mental imagery that have been associated with these anecdotal reports of historical creativity; it is especially relevant given that all of the studies to be reviewed use these reports as a primary justification for the study of mental imagery and creativity. This can be carried out by performing a simple citation count on the most frequently reported anecdotes of the use of mental imagery in creativity in six publications (see Table 4.1).

Of the anecdotal reports cited in the six publications only four were discussed by more than two of the authors. Einstein's use of mental imagery stands alone as an example of the type of mental imagery (waking-state and deliberate) that the individual differences approach aims to investigate in creativity research. In the other three reports mental images occurred in circumstances far removed from the individual differences measures used by imagery-creativity researchers. Typically, they were found in such contexts as: daydreaming, drug-induced states, hypnagogic and hypnopompic states, and dreaming. It is only when the less frequently cited examples are introduced that thought images receive a greater prominence in the creative process.

Table 4.1. Frequently cited anecdotal reports of the use of mental imagery in creativity (minimum citation = 2)

Author	Citations	Type of Imagery	Classification
Coleridge	4	opium induced	dream-associated
Einstein	3	experimental	wake-like
Kekulé	4	hypnagogic	dream-associated
Poincaré	2	daydream	dream-associated

Frequency of citation is derived from six publications which discuss the role of mental imagery in creativity: Finke (1991); Forisha (1978); Ghiselin (1952); Mavromatis (1987); Paivio (1983); and Shepard (1978a).

Study One. A Meta-Analytic Review of the Individual Differences Approach to the Association Between Self-reported Mental Imagery and Creativity

Introduction & Selection Criteria

Despite the relative infrequency of reports of the use of waking thought images in the creative process, the individual differences approach persists and the literature review of the empirical research shows that it remains the most common way of studying the two variables. Typically, these studies utilise an association paradigm in which a self-report measure of mental imagery is paired with a divergent thinking measure of creativity and both are performed in a standard test room environment. The self-report measure gauges an aspect of mental imagery (invariably visual) hypothesised to be necessary for its use in the thought process. The most notable examples are: the elaboration of mental imagery (Campos and Perez, 1989); the control of mental imagery (Forisha, 1981); and the vividness of mental imagery (Parrot and Strongman, 1985). Following the self-report measure participants are required to undertake the divergent thinking task in a standard test room environment.

A further characteristic of these studies is their emphasis upon the alleged ‘multifaceted’ nature of the role of mental imagery in creativity. This term has become an almost inevitable rejoinder to the ensuing findings; in the final set of six papers used in the meta-analysis below three of them apply this term. In recognition of the complexity of the role of mental imagery in creativity, these studies attempt to incorporate factors that may intervene or co-vary with mental imagery and creativity.

The initial selection of research papers pertaining to the individual differences approach to mental imagery and creativity was based upon computer data-base (PsychLit 1974-1997, and BIDS 1981-1997) and manual (in the Journal of Mental Imagery) searches. Together these searches yielded over 160 papers and books. Fifty-six were deemed to be significantly associated with mental imagery and creativity. Of these 30 were review or theoretical articles and 25 were empirical. Of the 27 empirical papers, 16 adopted the individual differences approach but only six fitted the criteria listed below. No attempt was made to locate unpublished studies but file drawer statistics are provided in the discussion section. The six papers selected for this meta-analysis of the individual differences approach employ essentially the same method of assessing the relationship between mental imagery and creativity. All have adopted the use of self-report measures of mental imagery and standard divergent thinking response measures. In addition all satisfied the criteria listed .

Order of presentation. As all of the studies employed self-report measures of mental imagery, only those that presented the self-report imagery measures first were employed. This requirement was based upon observations of demand characteristics in imagery self-report studies (Marks, 1998; McKelvie, 1995).

Response measures of divergent thinking. Given that all of the studies used a self-report measure of mental imagery, only studies which employed performance-based creativity scores (which were scored according to the authors instructions) with valid psychometric properties were included (e.g. Barron's Symbolic Equivalence Test, 1988; Torrance's Tests of Creative Thinking, 1972). Justification for this is based upon the proper methodological treatment of subjective measures in experimental psychology (see Valentine, 1992). Several papers were rejected on these ground (Campos and Gonzalez, 1993, 1994; Durndell and Wetherick, 1977; Kuzendorf, 1982).

Independence. In order to avoid the problem of multiple reporting only those studies which were clearly independent were included in the meta-analysis. A review paper by Forisha (1983) was rejected.

Mistakes, inadequate reporting, and sloppiness. Where non-significant associations were not reported and interpretation is not available through sample size and probability estimates, a Pearson correlation coefficient of $r=0.00$ was assumed (Rosenthal, 1991). Where evident mistakes have been made (e.g. misinterpreted significance tests) the

entire body of research from the author has been discarded (Khatena, 1972, 1973, 1975, 1978, and 1983).

Table 4.2. Papers and Books Retrieved in Data-base Searches Concerning the Relationship Between Mental Imagery and Creativity

Type	Authors
Theoretical and Review	Ahsen (1982); Anderson and Helstrup (1993); Cauthorne (1985); Daniels-McGhee and Davies (1994); Ernest (1977); Finke (1989, 1990, 1995); Finke, Ward and Smith (1992); Forisha (1978); Ghisilin (1955); Gardner (1993); Jennings (1991); Mavromatis (1987); McKellar (1957, 1995, 1997); Miller (1986, 1989, 1992); Montangero (1993); Paivio (1983); Partington (1964); Reiber (1995); Rothenberg (1979, 1995); Shepard (1978ab, 1984); Suler (1980); Tweney (1989).
Empirical	Antonietti, Bologna, and Lupi (1997); Bowers (1978); Campos and González (1993, 1994); Campos and Perez (1989); Durndell and Wetherick (1977); Finke and Slayton (1988); Forisha (1981); Hargreaves and Bolton (1972); Johnson (1979); Khatena (1972, 1973, 1975, 1978, 1983); Kuzendorf (1982); Lindauer (1977); Lynn and Rhue (1986); Parrott and Strongman (1985); Rothenberg and Sobel (1980); Shaw and Belmore (1982-83) Shaw and DeMers (1986); Sobel and Rothenberg (1980); Tushup and Zuckerman (1977)

Many of the problems associated with meta-analytic reviews have been circumvented through circumstance or selection criteria. For example, the ‘loss of information’ problem and the ‘counting apples and oranges’ issue (Glass, 1978) proved to be redundant as the empirical data were homogeneous. Similarly, deciding ‘good’ from ‘bad’ studies was facilitated by a large research literature into the operational validity and reliability of imagery questionnaires (Ashton and White 1980; Kihlstrom *et al.*, 1991; Marks, 1995, 1998; McKelvie, 1995).

Measures Employed

Using these criteria six papers were sufficiently rigorous to be included in the meta-analysis. The papers and the measures employed are listed in Table 4.3. In the six studies the participants' self-reported vividness and control of mental imagery were normally hypothesised to be associated with creativity. Marks' (1973) VVIQ was used in four of the studies. The alternative revised Betts' Questionnaire upon Mental Imagery (Sheehan, 1967) was employed in another study. A measure of self-reported control of mental imagery (A.Richardson's revised TVIC, 1969) was used in three of the studies and one study employed Slee's (1988) elaboration of mental imagery scale.

Table 4.3. Authors, Date of Publication(DP), and Measures Employed in the Six Studies Included in the Empirical Review

Authors	DP	Mental Imagery	Divergent Thinking
Bowers	1978	VVIQ	Guilford's Standard Consequences
Campos and Perez	1989	VES	Torrance's Figural TTCT
Forisha	1981	BQMI TVIC	Torrance's Verbal TTCT
Parrott and Strongman	1985	VVIQ TVIC	Torrance's Verbal and Figural TTCT
Shaw and Belmore	1982-3	VVIQ	Mednick's RAT and Torrance's Verbal and Figural TTCT
Shaw and DeMers	1986	VVIQ TVIC	Torrance's Verbal and Figural TTCT

The most commonly used measures of creative thinking were those taken from Torrance's battery of divergent thinking tests (e.g. Torrance, 1974). These tasks, based upon Guilford's structure of intellect model (Guilford, 1967), have been shown to be valid predictors of present and future creativity (e.g. Torrance, 1972, 1974, 1988). The other measures adopted were Guilford's (1967) Standard Consequences Task and Mednick's (1962) Remote Associates Test. Scant information was provided on the administration and scoring procedures adopted by the researchers. No attempts were made to assess or

control for loquacity effects in the scoring of the originality sub-measure of divergent thinking in those papers that used Torrance's TTCT (Hocevar, 1979).

Results

Age. While Chapter Three showed that some very specialised forms of mental imagery (e.g. paracosms and eidetic imagery) have been linked to specific age groups (Cohen and MacKeith, 1991; Haber, 1979), age has not been assessed in these six studies. Two of the studies used teenage participants (Campos and Perez, 1989; and, Shaw and DeMers, 1986), three used student-aged participants (Bowers, 1978; Forisha, 1981; and, Shaw and Belmore, 1982-3), and one used a full adult range (Parrott and Strongman, 1985). None of the studies provide justification for sample age selection and so it is assumed that the age range in these studies reflects sampling convenience.

Sex differences. It was noted in the previous chapter that sex differences in self-reported mental imagery have been reported and interpreted by many researchers (Ashton and White, 1980; Harshman and Paivio, 1987; McKelvie, 1995; Sheehan, 1967). Though there appears to be little theoretical basis for expecting sex-specific associations between mental imagery and creativity several researchers have reported such findings. Forisha (1981) found an association between self-reported imagery and creativity for males only. Conversely, Campos and Perez found a sex-specific association for females only. The fact that the other four studies failed to find sex-specific associations suggests that the significant findings could be due to statistical error.

Co-dependent Variables. Many of the papers under review perceived the relationship between mental imagery and creativity to be inter-linked with other variables. Forisha (1981), for example, considered socio-emotional maturity to effect the association between the two variables. Others investigated baseline intelligence (Shaw and DeMers, 1986), task instructions (Parrott and Strongman, 1985), effortless experiencing (Bowers, 1978), and verbal ability (Shaw and Belmore, 1982-3). Given the variety of co-dependent variables (and the fact that there have been no attempts to replicate the research) it is concluded that the only unifying factor is the association between mental imagery and creativity.

The Meta-Analysis. Of the six papers used in the meta-analysis only one produced a single statistical test (see Appendix 4.1). The majority have employed a range of measures of mental imagery and sub-measures of divergent thinking resulting in a mean number of 8.66 statistical tests per study. This variance in both the quantity of tests (see Table 4.3) and the ways of assessing the tests needs to be weighted so as to avoid the undue influence of any one study; for example, Parrott and Strongman (1985) report more than 40 statistical tests from two divergent thinking tasks while Shaw and Belmore (1982-83) report three statistical tests from three divergent thinking tasks. The solution adopted in the present study is to combine results for a study into a single effect size and significance level.

The combined results from each study were re-calculated into Fisher's r coefficients and a total weighted Fisher's r of 0.20 was derived from the six studies. A further analysis of the effect size was carried out in order to determine future sample size. This showed that sample sizes of 90 (or above) would produce the minimally acceptable (0.70) one-tailed power for individual differences studies.

Table 4.4. The Method of Mean Results for Six Studies of the Relationship Between Self-reported Mental Imagery and Creativity

Study	Tests and Participants	Lower Bound	Mean r	Upper Bound	Probability
Bowers	1 (22)	0.17	0.54	0.72	0.003
Campos and Perez	4 (122)	0.03	0.21	0.37	0.012
Forisha*	1 (320)	0.07	0.19	0.29	<0.001
Parrott and Strongman**	14 (70)	-0.19	0.05	0.28	0.413
Shaw and Belmore	3 (67)	-0.00	0.24	0.45	0.025
Shaw and DeMers	24 (141)	0.06	0.22	0.37	0.150
Total	47(752)	0.13	0.20	0.27	<0.001

* Provides a composite score

** Non-significant results were not reported so $z = 0.00$, $r = 0.00$, and $p = 0.50$ is assumed (see Rosenthal, 1991).

The initial analysis of effect size was complemented by further tests of homogeneity, directional trend, and overall significance. A test of heterogeneity was not significant ($\chi^2(5)=4.99$, $p>0.05$) thereby permitting further analysis to be conducted on the combined scores. An assessment of directional trend was carried out using a z transformation of the proportion of positive signs across the six studies. This was significant ($z=4.76$, $P<0.001$) thereby supporting the observation that the combined Fisher's r coefficients were consistently positively associated. As a combined result the lower bound confidence interval lies above the standard threshold and the weighted mean value of Fisher's r (accounting for 4% of the variance shared between the two variables) is adjudged to be marginally supportive of a criterion relationship between the two variables .

Characteristics of Mental Imagery

The researchers focused mainly upon two characteristics of mental imagery, namely, vividness and control. As three of these studies measured both aspects of mental imagery (Forisha, 1981; Parrott and Strongman, 1985; and, Shaw and DeMers, 1986) a sufficient number of results are available to enable separate meta-analyses. Five of the studies used a vividness measure of mental imagery. The results from these studies are presented in Table 4.5.

Table 4.5. Fisher's r Correlation Coefficients for studies Employing a Measure of the Vividness of Mental Imagery

Author	Participants and Tests	Lower Bound	Mean r	Upper Bound	Probability
Bowers	32 (1)	0.17	0.54	0.72	0.003
Forisha	320(3)	-0.07	0.04	0.15	0.237
Parrott & Strongman	70 (7)	-0.13	0.11	0.34	0.179
Shaw & Belmore	67(3)	-0.00	0.24	0.45	0.024
Shaw & DeMers	141(12)	0.10	0.26	0.41	0.001
Total	630(26)	0.06	0.14	0.22	<0.01

The overall Fisher's r for those studies employing a vividness measure of mental imagery was 0.14. A test of heterogeneity was not significant ($\chi^2(4)=8.11$, $p>0.05$) thus

confirming that the results were homogeneous. A combined analysis of the criterion validity of the vividness of mental imagery and creative performance was significant ($z=2.87$, $p<0.01$). Assessment of confidence intervals showed that the standard was exceeded but the judged importance of the criterion relationship was defined as ‘inconsequential’ with less than 2% of the variance shared between the two variables (Cohen, 1992; McKelvie, 1995).

Table 4.6. Fisher’s r Correlation Coefficients for studies Employing a Measure of Control of Mental Imagery

Author	Participants and Tests	Lower Bound	Mean r	Upper Bound	Probability
Forisha	320(3)	0.07	0.18	0.29	<0.000
Parrott & Strongman	70 (7)	-0.18	0.06	0.29	0.307
Shaw & DeMers	141(12)	0.04	0.20	0.35	0.008
Total	531(22)	0.09	0.17	0.25	<0.000

Though only three studies employed a measure of the control of mental imagery one of the studies (Forisha, 1981) contained a sufficiently large sample size to enable reliable estimations to be produced. The same procedure was applied to assess criterion validity and the results are listed in Table 4.6. Overall the control of mental imagery measure showed a slightly stronger association with creative performance than the vividness measure. The findings were homogeneous with all of the studies reporting a positive association between the control of mental imagery and performance on the divergent thinking tasks ($\chi^2(2)=1.65$, $p>0.05$). The results, when treated as a combined sample, were significant ($z=3.27$, $p<0.001$). Examination of the confidence intervals shows no overlap in the criterion relationship and the overall association (accounting for 4% of the variance in the two variables) was judged to be of ‘marginal’ relevance to the imagery-creativity hypothesis (McKelvie, 1995).

Types of Creativity

Theoretically it would be expected that a person who reports more vividness and control of mental imagery would also perform a figural task better than a verbal task. This

simple hypothesis was evaluated through separate analyses of the figural and divergent thinking scores. The results of these analyses are presented in Tables 4.7 and 4.8.

Table 4.7. Fisher's r Correlation Coefficients for studies Employing a Measure of Verbal Creativity

Author	Participants and Tests	Lower Bound	Mean r	Upper Bound	Probability
Bowers	32 (1)	0.17	0.54	0.72	0.003
Forisha	320(3)	0.08	0.19	0.29	<0.001
Parrott & Strongman	70 (7)	-0.24	0.00	0.24	0.500
Shaw & Belmore	67(2)	-0.02	0.22	0.44	0.036
Shaw & DeMers	141(12)	0.01	0.17	0.33	0.022
Total	630(26)	0.11	0.19	0.26	<0.001

Five studies employed verbal divergent thinking measures as part of their battery of tests. All of the findings were in the predicted direction and were sufficiently homogeneous to enable a combined analysis ($\chi^2(4)=6.00$, $p>0.05$). The combined scores were significant ($z=4.39$, $p<0.001$) with a marginally useful weighted Fisher's r of 0.19.

Table 4.8. Fisher's r Correlation Coefficients for studies Employing a Measure of Figural Creativity

Author	Participants and Tests	Lower Bound	Mean r	Upper Bound	Probability
Campos & Perez	122(4)	0.03	0.21	-0.37	0.010
Parrott & Strongman	70 (7)	-0.07	0.11	0.34	0.179
Shaw & Belmore	67(1)	-0.05	0.29	0.50	0.009
Shaw & DeMers	141(12)	0.10	0.26	0.41	0.001
Total	400(25)	0.14	0.23	0.32	<0.001

Four of the six studies provided separate statistical tests for figural divergent thinking. The scores were all in the same direction and a chi-square analysis showed they were homogeneous ($\chi^2(3)0.71$, $p>0.05$). Overall the scores on the four studies were

significant ($z=4.71$, $p<0.001$) and the combined weighted Fisher's r showed that the association was slightly larger (but not significantly so) for the figural tasks than for the verbal task.

Discussion

Following database searches and the implementation of conservative selection criteria six studies were assessed using a meta-analytic procedure. The results from these studies were then collapsed into an overall weighted Fisher's r and tests of homogeneity, trend, and significance were carried out. The overall findings suggest that there is a small association between self-reported mental imagery and divergent thinking (Cohen, 1991). They also show that the results from the six studies are consistently positively associated and that the overall effect size is significant; using Rosenthal's (1991) file drawer solution 44 non-significant results would have to be produced to nullify this result. Separate analyses by type of mental imagery showed that the control of mental imagery had a slightly larger association with creative performance than the vividness measures. It was also observed that stronger effects emerged when figural divergent thinking tasks were used, as opposed to verbal divergent thinking tasks. In both cases, however, it is stressed that the coefficient differences were not large enough to warrant a theoretical interpretation.

These analyses suggest that there is some empirical support for the hypothesised association between self-reported mental imagery and performance on creativity tasks. Furthermore, given the conservative selection criteria used in this meta-analysis the effects are less susceptible to such artifacts as: social desirability, task demand, or the 'file-drawer' effect. However, the overall weighted Fisher's r controlled less than 5% of the variance in the data sets. According to McKelvie's (1995) assessment of the criterion validity of self-report measures, this would fall into the lower 'marginal' judgement of acceptability. Finally, it should be acknowledged that though the weighted Fisher's r reveals a significant relationship between the two variables, it does mask a series of problems with the research area.

The first problem concerns inconsistent and contradictory results when specific self-report measures are viewed. This inconsistency was revealed because several of the studies utilised more than one measure of mental imagery. The problem is highlighted

when comparing Parrott and Strongman's (1985) findings with those of Forisha (1981). Both studies used measures of control and vividness of imagery but only Forisha found a consistent significant association between the control of mental imagery and creativity. Parrott and Strongman (1985), however, found several significant associations between the vividness of imagery and creativity where Forisha did not. These findings, masked by the meta-analysis, suggest that these inconsistencies need to be resolved before any consideration for a third intervening variable is made.

A similar situation occurs when the findings are divided according to the type of divergent thinking task. Divergent thinking tasks are broadly categorised into a verbal or figural presentation format. Experimentally (Brooks, 1967; Marks, 1972, 1973) and theoretically (Paivio, 1971; Kosslyn, 1980; and Shepard, 1984) it would be expected that a stronger association between imagery measures and figural tests would be found. However, the results only just conform to this expectation. Of the 47 tests analysed (19 figural and 22 verbal), eight of the verbal tests and thirteen of the figural tests were significant.

It is possible that both of the problems described above are due in some part to the differing ways in which the tasks are measured and understood. For example, two of the studies used total divergent thinking scores (Bowers, 1978; Shaw and Belmore, 1982-3), three of the studies used the standard three sub-measures (fluency, flexibility, and originality) of divergent thinking (Campos and Perez, 1989; Forisha, 1981; and Shaw and DeMers, 1986), and one study used added a fourth sub-measure (elaboration) of divergent thinking (Parrott and Strongman, 1985). Furthermore, no attempt was made to assess the structure of the self-report measures prior to carrying out the study, despite the fact that much controversy persists over the validity and reliability of these measures (Ahsen, 1985; Hiscock, 1978; Kihlstrom *et al.*, 1991; Marks, 1995, 1997; McKelvie, 1995; and, J.T.E. Richardson, 1988)

A final area of uncertainty concerns the range of co-dependent variables under investigation by the researchers. The use of these variables is sometimes based upon *a priori* factors such as Shaw and DeMers' claim that a baseline intelligence is necessary for the use of mental imagery in creativity; borrowed perhaps from the view that a baseline intelligence is necessary for creativity (see Butcher, 1968). Parrott and Strongman (1985) claim that the association is determined by a variety of factors such as:

task demands, environment, and creative orientation; no reference is made to intelligence. Meanwhile, both Forisha (1981) and Campos and Perez (1989), argue that sex differences are important in assessing the relationship between mental imagery and creativity. The problem is that when viewed collectively they fail to provide a coherent body of knowledge. That is, they represent an inability to progress beyond the basic supposition that mental imagery is associated with creativity.

Conclusion

A meta-analysis was carried out on six studies of self-reported mental imagery and divergent thinking selected on the basis of four criteria. Results indicated that there was a small association between the two variables and that this effect was consistent across the range of studies. While these results show a relevance for continued research, they expose some serious problems with the research area. These centre upon the variable scoring procedures adopted, a failure to assess the psychometric properties of the self-report measures, and a general lack of clarity arising from a need to identify why and how mental imagery is associated with creativity.

Given the problems noted in the meta-analysis, it is necessary to carry out further investigation into the association between self-reported mental imagery and performance on creativity tests. It is proposed that this should start from an uncomplicated assessment of the association between the two variables. This could be carried out by selecting the two aspects of mental imagery most frequently assessed in the previous research, namely the control and vividness of mental imagery, and adding a third creativity-specific self-report measure of mental imagery. These measures could then be evaluated in the context of figural and verbal divergent thinking measures. Initially, however, an assessment of the psychometric properties of the self-report measures is required. This is the aim of the next chapter.

Chapter V

Individual Differences in Self-Reported Mental Imagery and Divergent Thinking Performance. Psychometric and Criterion Validity Analyses.

General Introduction

The results from the meta-analytic procedure carried out in the previous chapter suggested that there was a small association between self-reported mental imagery and divergent thinking. Closer inspection showed small differences in effect size for the characteristics of mental imagery (control and vividness). However, the differences between these characteristics were not large enough to warrant *post facto* explanation. Furthermore, it was also found that an expected effect of divergent thinking task format, figural or verbal, was less evident than expected on theoretical grounds.

Following analyses of the previous research a closer inspection of data trends by characteristic of mental imagery and form of divergent thinking revealed several inconsistencies. Both of the variables under investigation were measured in different ways. Mediating variables were not used by later researchers and the results from several studies produced striking contradictions pervading every aspect of the methodology. After all of these factors had been taken into account, the one consistent empirical observation remaining was the simple supposition that mental imagery is in some way associated with divergent thinking performance.

As the basic association between mental imagery and divergent thinking was the only reliable inference drawn from the meta-analysis, the aim of the present chapter is to assess this relationship as rigorously as possible. That is, to take the basic components of the individual differences approach and, where possible, to empirically evaluate their psychometric properties. Once this has been realised it should be possible to provide additional empirical information about the individual differences approach and to re-evaluate the association between self-report measures of mental imagery and divergent thinking. The areas of interest are those presented in the meta-analytic review, namely, the two most frequently assessed characteristics of mental imagery (control and vividness) and the standard formats employed in divergent thinking tests (figural and verbal).

As the predictive validity of divergent thinking measures requires access to special populations and the use of longitudinal designs the focus of psychometric evaluation in this chapter is upon the self-reported measures of mental imagery used in the individual differences approach. The aim of the following studies is to evaluate the construct nature and internal reliability of self-report measures of mental imagery.

Following this procedure the products can be employed to investigate their association with divergent thinking performance.

Study Two. The Construct Validity and Reliability of the Eyes-Open Version of The Vividness of Visual Imagery Questionnaire

Introduction

The Vividness of Visual Imagery Questionnaire was developed by Marks (1972,1973). It has been used in over 150 studies of mental imagery and was the most common self-report measure employed in the studies of imagery and creativity. In the past five years it has been the subject of review papers focusing upon its criterion validity (e.g. McKelvie, 1994, 1995; Marks, 1995, 1998). Although there has been a large number of studies investigating the criterion validity of the questionnaire, the author is unaware of a single published study which has independently assessed the internal factor structure of the VVIQ. Previous studies of the factor of the VVIQ were unpublished as the apparent unitary structure was thought to be of little interest (Marks, 1999, personal communication).

While McKelvie (1995) and Marks (1998) provide excellent reviews of the predictive utility and criterion validity of the VVIQ, research into its factor structure hardly exists. This is most clearly seen in the small number of factor and principle component analyses reported by researchers; one of the main statistical tools used to study validity (Tabachnick and Fidell, 1989). A review of the literature reveals that only two factor analytic studies have been cited and the first of these remains unpublished but frequently cited via its secondary source (White, Sheehan, and Ashton, 1977). This study, carried out by Dowling in 1973, found a single unitary factor, thereby supporting the view that the VVIQ measures a single vividness dimension.

A second study, carried out by Kihlstrom *et al.* (1991), investigated the TVIC and the VVIQ (separate measures were not taken for eyes-open and eyes-closed) in a single factor analysis. This research, carried out on over 700 participants, found a four factor solution for the VVIQ with factors corresponding to the four item clusters. This study is seldom referred to and the majority of researchers continue to adopt a single factor concept when scoring the VVIQ.

Clearly, the concept of unity is so implicit in the construct that a factor analysis was deemed to be of secondary importance to the various issues of reliability. These are far more common and cover the full spectrum, including split-half, alpha, alternate-form, and test-retest. In McKelvie's (1995) review of the research into reliability he reports acceptable to good coefficients for split-half, alpha, and test-retest reliability, but unacceptable coefficients for the alternate-form studies, an issue contested by Marks in his reply to McKelvie (Marks, 1995).

In general it can be concluded that the studies reviewed by McKelvie (1995) support the underlying theme of a single unitary factor measuring the vividness of visual imagery. However, without the fundamental analysis of the factor structure provided by principle component or factor analytic statistics, it is not possible to empirically support this notion. Furthermore, given the nature of the VVIQ, it would not be unreasonable to assume that it involves a variety of aspects of mental imagery and that the usual technique of summation (or item averaging) may be inadequate. Indeed this view has been put forward by several researchers who have used the VVIQ and have suggested alternative scoring techniques (Reisberg and Hauer, 1988; McKelvie, 1995). These include, taking the maximum imagery score, the median score or even the modal score.

In summary, there has been a considerable amount of research into the VVIQ. This has tended to focus upon measures of reliability and construct validity which clearly show good psychometric properties. However, there has not been a study of the factor structure that firmly establishes the usual scoring method. This is the aim of the present research which adopts a simple exploratory approach to the construct validity and internal reliability of the factor/s underlying the VVIQ.

Method

Participants. One-hundred and ninety-eight psychology undergraduates from Middlesex University completed the eyes-open version of the VVIQ. Analyses of age and sex are included in the results.

Materials. The VVIQ used in the present research is the 16 item, eyes-open version. Marks' original VVIQ consisted of 16 items rated twice, once with 'eyes open' and once with 'eyes closed'. Justification for assessing only the eyes-open scores is based upon the needs of the future research into creativity where eyes open is the *modus*

operandi. The VVIQ consists of four blocks of to-be-imaged scenes with four corresponding item statements (see Table 5.1). The rating procedure for the VVIQ is performed per item with a range of 1 (“perfectly clear and as vivid as normal vision”) to 5 (“no image at all, you only “know” that you are thinking of an object”). The eyes-open version of the VVIQ is presented in Appendix 5.1.

Procedure. The questionnaire was given to the participants as part of several batteries of tests. In all of these studies the eyes-open VVIQ was presented in a test-room environment with less than four participants’ present. The participants were informed that they should complete the questionnaire as quietly, quickly, and honestly as possible. The eyes-open version of the questionnaire takes approximately ten minutes to complete.

Statistical Procedures. Following screening for univariate and multivariate normality the internal construct of the eyes-open VVIQ was assessed through a Principal Components Analysis (PCA), followed by oblique rotation using oblimin. Internal consistency of the factors was assessed using Chronbach’s alpha.

Results

The average age of the participants was 23.86 with a median age of 22 (7 people failed to state their age). The ages ranged from 18 to 47. There was a non-significant association between age and VVIQ rating ($r(189)=0.016$, $p > 0.05$). Seventy-five males and one-hundred and twenty-three females took part in the factor analysis. An independent groups t-test showed no significant differences between males and females on their VVIQ ratings ($t(196)=0.05$, $p > 0.05$).

Data Screening and Adjustment. The VVIQ was presented to the participants in the eyes open only format giving a minimum possible item average score of 1 indicating high imagery (an item total score of 16) and a maximum possible item average score of 5 indicating low imagery (an item summed score of 80). The overall item average score produced from the 198 participants was 2.32 with an item average range of 1.89 (“You enter the shop and go to the counter. The counter assistant serves you. Money changes hands.”) to 2.79 (“The precise carriage, length of step, etc. in walking.”). A one-sample t-test showed that the individuals generally rated their imagery as higher than the expected average vividness ($t(197)=-13.82$, $p < 0.001$). This response leniency is consistent with previous research using the VVIQ (see McKelvie, 1995). The scores are very similar to

those found in a recent review of 38 studies where VVIQ item means are reported (McKelvie, 1995: Mean = 2.307, Standard deviation = 0.677).

Table 5.1. Representation of Item loadings Following an Oblique Rotation (Loadings greater than 0.40 Shown) for the Sixteen Vividness of Visual Imagery Questionnaire Items (n=198)

VVIQ Items	'Nature'	'Person'	'Shop'
The exact contour of face, head, shoulders and body		0.81	
Characteristic poses of head, attitudes of body, etc.		0.76	
The precise carriage, length of step, etc. in walking		0.86	
The different colours worn in some familiar clothes		0.48	
The sun is rising above the horizon into a hazy sky	0.68		
The sky clears and surrounds the sun with blueness	0.47		
Clouds. A storm blows up, with flashes of lightening	0.87		
A rainbow appears	0.63		
The overall appearance of the shop from the opposite side of the road			0.73
A window display including colours, details of individual items for sale			0.83
You are near the entrance. The colour, shape and details of the door			0.77
You enter the shop and go to the counter. The counter assistant serves you. Money changes hands			0.57
The contours of the landscape	0.75		
The colour and shape of the tree	0.60		
The colour and shape of the lake	0.74		
A strong wind blows on the trees and on the lake causing waves	0.78		

Initial screening of the data set yielded a significant positive skew on six of the sixteen items (Items 1,2,4,6,9, and 12) using a z transformation with $p < 0.001$: necessarily conservative due to the large sample size (see Tabachnick and Fidell, 1989).

Square root transformations for five of the six items produced a non-significant skew and a logarithmic transformation for Item Twelve resulted in a non-significant skew.

A Principal Components Analysis (PCA) was used to determine the number of factors derived from the 16 items. Three factors, accounting for 58.6% of the variance in the data set, were found with an eigenvalue > 1 . This contrasted with the Scree method which extracted one or possibly two factors (see Appendix 5.2). As the factors were not orthogonal (see Table 5.2) a further PCA, with an oblique rotation and a three factor solution, was carried out. This produced the most parsimonious solution with clearly identifiable groups emerging (see Table 5.1).

Table 5.2. Correlation Matrix of The Three Factor Solution (n=198)

	Person scene	Shop scene
Nature scenes	0.49	0.52
Shop scene	0.48	

The main factor (accounting for 43.1% of the variance in the data set) consisted of two of the four blocks on the VVIQ. These were items five to eight and thirteen to sixteen. This factor was labelled 'Nature Scenes' as this most adequately described the eight items. To ascertain inter-item homogeneity the eight items were subjected to a Chronbach's Alpha. The total Alpha reliability coefficient was 0.88 with a mean inter-item correlation of 0.49 ranging from 0.31 to 0.67. Alpha reliability coefficients when items were singularly removed showed that all contributed to the overall reliability of the measure (see Appendix 5.3).

The second factor (referred to as 'Person scene') accounted for 8.7% of the variance with four items (those from block one of the VVIQ) loading above 0.4. A Chronbach's Alpha analysis yielded an overall reliability coefficient of 0.80 and a mean inter-item correlation coefficient of 0.51; ranging from 0.42 to 0.62. Alpha reliability coefficients when each item was removed showed that Item Four depressed the overall Alpha coefficient. However the scale of the depression was too small to warrant the exclusion of the item (see Appendix 5.4).

The final factor accounted for only 6.8% of the variance. However as four items loaded (those from block three of the VVIQ) above 0.4 on the factor and the eigenvalue

was greater than one it was included in the final solution. This factor was labelled 'Shop Scene' as the underlying theme of the to-be-imaged items referred to a shop context. A Chronbach's Alpha analysis yielded an overall reliability coefficient of 0.76. Though lower than the coefficients produced in the two previous analyses, this is still within the acceptable range. A mean inter-item coefficient of 0.45 was found with a range of 0.36 to 0.52. Chronbach's Alpha Reliability coefficients when each item was removed showed that all of the items contributed to the reliability of the scale (see Appendix 5.5).

Following the PCA and reliability analyses item averages for the three eyes-open VVIQ factors were computed. These showed that participants rated the first factor most vividly (mean=2.23), the second factor as averagely vivid (mean=2.38) and the third factor as the least vivid (mean=2.43). A repeated measures ANOVA was carried out on the item average vividness scores for the three factors. This showed that the three eyes-open VVIQ groupings produced different responses ($F(2, 391)=7.90$, $MSe = 0.27$, $p<0.001$).

Discussion

Initial screening of the data showed that the participants' exhibited a response leniency similarly reported by previous researchers (see McKelvie, 1995). It also showed that scores for the VVIQ were very similar, in the context of response leniency and distribution, to those found by previous researchers. In general, however, the VVIQ has reasonably good parametric properties and where problems occur (e.g. positive skewness) they could be easily resolved through data transformation.

The most controversial finding from the present analysis is the discovery of a three factor solution for the eyes-open version of the VVIQ. As was noted in the introduction, previous research using the VVIQ has assumed that the scale represents a single factor, namely, the vividness of visual imagery; the Kihlstrom *et al.* (1991) solution needs to be assessed in the context of the control of imagery measure included in the analysis. However, the results from the factor analysis are ambiguous as the standard methods of determining solutions (i.e. eigenvalues > 1 ; and the scree plot analysis) do not conform and it is necessary to interpret the most elegant solution. While the scree plot solution fits better with *a priori* considerations (based upon combined eyes-open and eyes-closed scores), it explains less than 45% of the variance in the data set.

Conversely, the eigenvalue method accounts for 59% of the variance and when the factors were subjected to an oblique rotation a clearly interpretable solution was found. Underlying the solution is the notion that in an eyes-open format the vividness of visual imagery may vary according to the content of the item and, in the case of the VVIQ, the theme of the block of items. Hence, the three factor solution partially corresponds with the block contents of the VVIQ. This is further supported by the finding that the response averages to the three factors were significantly different.

In summary, there is no reason to believe that the ratings producing the present results differ from those of previous researchers using the eyes-open version of the VVIQ. This is because the same range of responses were observed in this study as those found in other research (see McKelvie, 1995). When the eyes-open version was assessed through the PCA oblique rotation method two possible factor structures emerged. The first, a unitary factor, concurred with previous unpublished analyses employing the full version of the VVIQ (Marks, 1999, personal communication). The second, a three factor solution, concurred with expectations concerning variation caused by the context of the to-be-imaged items. As a choice is required, the three factor solution has been adopted as an interesting and possibly fruitful way of deriving implicit self-report averages.

Study Three. The Construct Validity and Reliability of the Test of Visual Imagery Control

Introduction

While an understanding of the VVIQ's functional utility has been enhanced by some excellent reviews (Marks, 1998; and McKelvie, 1995) the TVIC has received less thorough attention. There has, however, been more research into the validity and reliability of the TVIC which means that some predictions can be made on the basis of prior research rather than common practice.

There have been many studies of the various forms of reliability and the majority of these are reported in White *et al.*'s (1980) review of the psychometric properties of imagery self-report measures. Research into inter-item association has produced mixed findings with some researchers reporting good internal reliability (White, Sheehan and Ashton, 1976) and others reporting poor internal reliability (Westcott and Rosenstock,

1976). Test-retest properties of the TVIC have been defined as adequate (White *et al.*, 1977) and alternate-form studies tend to out-perform those of vividness measures (McKelvie and Gingrass, 1974).

There have also been several factor analytic studies of the TVIC the most notable of which, in terms of sample size, were those carried out by Ashton and White (1974) and Kihlstrom *et al.* (1991). The former gave 1562 introductory psychology students A.Richardson's (1969) 12 item version of the TVIC. An orthogonal rotation revealed that the TVIC consisted of three (presumably independent) factors. A later study by Kihlstrom *et al.* (1991) in which 2,075 students completed the revised Betts QMI (Sheehan, 1967) with the Richardson TVIC reported a six factor solution with the TVIC loading on four of these factors. This study also used an orthogonal rotation so it must be assumed that the factors were independent; this is curious given the findings from the studies of internal consistency.

In summarising this brief review of the psychometric properties of the TVIC, it can be concluded that the measure generally performs well on assessments of reliability but there seem to be problems with its internal structure. Although it was designed to assess a single dichotomous factor of imaging (control), the version adapted by A.Richardson (1969) appears to have a complex, multi-factorial structure.

Method

Participants. One-hundred and sixty seven psychology undergraduates from Middlesex University completed the TVIC. The sample consisted of 115 females and 52 males with a median age of 20, and a range of 18 to 52. Six participants failed to complete the questionnaire appropriately and were therefore excluded from all further analysis.

Materials. The original TVIC was rated in a forced choice format with respondents giving 'Yes' and 'No' responses to eleven items pertaining to a car. A.Richardson (1969) inserted a twelfth item and included an 'Unsure' response. This scale is most commonly used by mental imagery researchers and is scored on a scale of 0 to 24 ("Yes"=2, "Unsure"=1, "No"=0). In the present study the Richardson version was used (see Appendix 5.6).

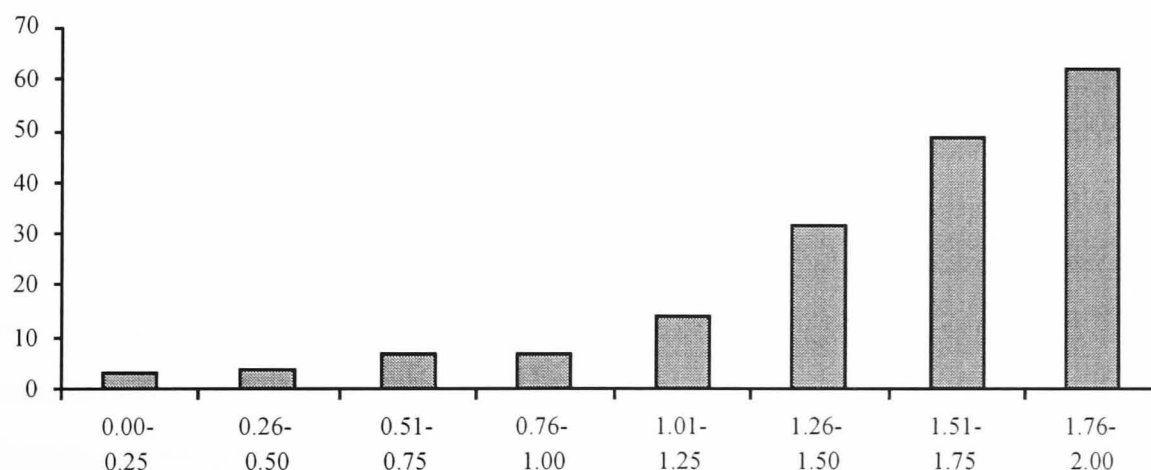
Procedure. The questionnaire was given to the participants for self-completion in a test-room format. The participants were informed that they should complete the questionnaire as quietly, quickly, and honestly as possible. The questionnaire takes slightly less time to complete than the VVIQ.

Statistical Procedure. The aim of the study is to assess the construct validity and internal reliability of the TVIC. This is to be achieved by carrying out the same statistical techniques that were applied to the VVIQ.

Results

The summed item scores for the participants averaged 18.53 with a standard deviation of 5.49. The item means ranged from 1.25 ('a car with a couple inside') to 1.88 ('a car standing in the road'). Overall these scores are similar to those presented by Kihlstrom *et al.* (1991). As the possible range of item scores was zero to two it is evident that the TVIC produces the same ceiling effects found in other measures of self-reported mental imagery.

Figure 5.1. Frequency Counts (Y AXIS) for Participants' Item Mean Scores on the Test of Visual Imagery Control Questionnaire



Prior to carrying out psychometric tests the data set was screened for univariate normality. This screening revealed a consistent negative skew (see Table 5.3) in all of the items and problems with kurtosis in six of the twelve items. The data set was not amenable to the usual transformation procedures (including reflection and inversion) and the total item average also showed significant skew and kurtosis.

Table 5.3. An Examination of the Skewness and Kurtosis of the Items from the Revised Gordon Test of Visual Imagery Control (n=161)

TVIC Item	Mean	St.Dev.	Skewness (se=0.19)	Kurtosis (se=0.38)
A car standing in the road	1.88	0.42	-19.37**	34.00**
A car in colour	1.62	0.75	-8.37**	1.89
A car in a different colour	1.29	0.88	-3.11**	3.84**
A car upside down	1.57	0.76	-7.21**	0.34
A car upright again	1.77	0.61	-12.79**	10.97**
A car moving on the road	1.61	0.73	-8.05**	1.66
A car climbing a hill	1.61	0.74	-8.11**	1.61
A car climbing over the top	1.55	0.80	-7.00**	-0.21
A car crashing through a house	1.42	0.84	-4.89**	-2.47*
A car moving with a couple inside	1.25	0.89	-2.68*	-4.11**
The car falls into a stream	1.57	0.75	-7.26**	0.61
A car dismantled	1.40	0.86	-4.58**	-2.87*
Item mean	1.54	0.46	-6.58**	-3.37**

*p < 0.01; **p < 0.001

While it is recommended that statistical tests of skewness and kurtosis are interpreted cautiously because significant results found with large samples often deviate only marginally from the normal distribution (Tabachnick and Fidell, 1989) graphical representations of the items and the summed average item score (see Figure 5.1) showed that a response leniency was pervasive throughout the measure. As all attempts to normalise the data set failed, it was concluded that any multivariate inference drawn from the data set would not be reliable and no further analysis was performed.

Discussion

The results from the present study do not bode well for the use of this measure in subsequent research. The failure to go beyond the basic univariate screening procedure suggests that this measure should not be used as a continuous variable. Furthermore, given the reasonably large sample size and the similarity between the responses in this

and previous studies (e.g. Kihlstrom *et al.*, 1991), it is unlikely that these findings are a quirk of this particular study.

Undoubtedly the problem arises from a response leniency. This is not surprising as the TVIC was not designed as an interval scale (Gordon, 1949). However, its modification by A. Richardson (1969) means that it can also no longer be used as a dichotomous measure of 'controlled' and 'autonomous' imagery. This is because the number of respondents who report maximum scores on the TVIC (controlled imagers) now represents only a small proportion of the respondents; in the present study it was 23%. Furthermore, it would not be sensible to return to Gordon's original scoring procedure as the addition of (and the participants willingness to use) the 'Unsure' response suggests that any measure of mental imagery control should not be of a forced choice nature.

One possible solution to the problem would be to use some form of division to create quasi-experimental groupings. Clearly a median split would not be appropriate as it would be completely at odds with the original version of the TVIC. Forming blocks of graduated imagery autonomy, similar to those used by Khatena (1975) may represent one possible solution. However, in order to do this it would be necessary to ignore previous factor analytic studies which have found that the TVIC does not measure a single construct (Ashton and White, 1974; and, Kihlstrom *et al.*, 1991).

There are good methodological reasons for disregarding the previous research into the construct of the TVIC. One of these is that if the internal reliability studies are taken into account (see White *et al.*, 1977) then an orthogonal rotation should not have been employed as it does not demonstrate the reality of the data set. In order to test this claim a dummy PCA was carried out on the present data set. This showed a similar three/four factor solution to that found in the previous research with all of the factors exceeding the standard 'oblique' threshold of 0.3 (Tabachnick and Fidell, 1989). Furthermore, while the overall scale showed good internal reliability the separated factors demonstrated poor reliability. These findings, which should not be statistically relied upon, do show that the present data set is very similar to that found in previous studies. They therefore support the contention that these studies should not be acted upon in future empirical inquiry.

In summarising the findings from the present study it has been shown that the TVIC does not meet the minimal requirements for a multivariate analysis. This is due to a

response leniency inherent in many self-report measures but too extreme in the case of the TVIC to allow it to be used as an interval scale measure. Given the inadequacy of the TVIC the ideal solution would be to develop a new measure of the control of mental imagery. However, as this is beyond the remit of the present research, the alternative procedure of blocking for gradations of 'autonomy' will be applied.

Study Four. The Relationship between the Vividness and Control of Visual Imagery and Verbal and Figural Divergent Thinking

Introduction

The aim of the present study is to investigate the role of the vividness and control of mental imagery in creativity. To do this two performance measures of divergent thinking are assessed in the context of the two mental imagery self-report measures whose psychometric properties were evaluated in the previous two studies. The variables selected as creativity measures are two shortened versions of the Torrance Tests of Creative Thinking (TTCT). In the following section hypotheses pertaining to the two mental imagery self-reports are discussed. Initially, however, a short review of the TTCT is undertaken.

The Torrance Tests of Creative Thinking

The most frequently cited measures of divergent thinking employed by researchers of mental imagery and creativity are derived from the battery developed by Torrance (e.g. Torrance, 1972, 1974), and called The Torrance Tests of Creative Thinking (TTCT). The TTCT is presented in two forms (figural and verbal) and is scored according to three abilities: fluency of responses, frequency of responses, and originality of responses. Two Torrance Tests of Creative Thinking are employed in the study

The TTCT follows the factor analytic tradition developed by Galton, Pearson, and Spearman, and continued by Thurstone, Burt, Guilford, and Eysenck. The main emphasis of the early research focused on intelligence and personality and there was little attempt to expand upon the work of Binet, Henri, Terman, and others into creative thinking (see Ochse, 1990). This changed following Guilford's APA address in 1950 and his considerable work into the sub-divisions of intelligence. Guilford (1967) claimed that

intelligence consisted of three factors: operation, content, and production. Operation, it was argued, could take place in five specific ways: cognition, memory, divergent production, convergent production, and evaluation. Divergent production referred specifically to Guilford's concept of creative production. Thus, Guilford considered creativity to be distinguishable from other forms of intelligence as it was expressed through divergent production. Guilford's further contribution to the factor analytic approach was his decision to divide the operation of divergent thinking into four forms of problem solving ability: sensitivity to problems; fluency; flexibility; and originality.

The TTCT, developed by Torrance in the 1960s and 1970s, followed very much in the tradition of Guilford's concept of divergent production. Torrance (1974) adopted Guilford's abilities approach to problem solving through the development of four divergent thinking (DT) sub-measures applied across a basic figural/verbal dichotomy. Three of these (fluency, flexibility, and originality) were derived from Guilford and a fourth (elaboration) was developed by Torrance himself.

Guilford's application of his structure of intellect model resulted in the use of timed-tests to measure creativity. These have been questioned by researchers in respect of their predictive and construct validity (Wallach & Kogan, 1965; Barron and Harrington, 1981). Though there are probably numerous reasons why Torrance's tests have superseded those of Guilford as the most frequently used measure of DT (e.g. easy availability, extensive use, breadth of tasks, and comprehensive scoring materials) the fact that Torrance had attempted to address the predictive and construct validity of his battery makes it very attractive to a quantitative approach (see Torrance, 1974, 1988). These studies suggest that his tests have the ability to both distinguish creative and non-creative individuals and to predict future real-life creative performance. This may explain why the Torrance Tests were selected by researchers interested in the role of mental imagery in creativity.

The Vividness of Visual Imagery

On the basis of several sources of information it is now possible to come to some conclusions concerning the relationship between the self-reported vividness of visual imagery and creativity. Firstly, it has been noted that many historically creative people claim to have employed mental imagery in the development of their ideas. Clearly

vividness is an important dimension of visual imagery as the clarity of the image is an essential component in the interpretation procedure. Secondly, the VVIQ has a long history of use in individual differences research. It has also been used in a large number of criterion studies utilising performance measures of cognitive ability (see McKelvie, 1995). Furthermore, the meta-analytic procedure showed that it has been used in a number of studies of mental imagery and creativity (e.g. Parrott and Strongman, 1985). Thirdly, research from the present chapter has established good construct validity with three related but distinguishable factors emerging from an oblique rotation. These scales also yielded good internal reliability coefficients.

What is not clear from the meta-analytic review is which forms of divergent thinking format (figural/verbal) and measures (fluency, flexibility, or originality) are related to imagery vividness. Unfortunately, the data from previous research using the VVIQ and the TTCT has not been consistent enough to establish a pattern of content and ability. Furthermore, the results from the factor analysis yielded a new form of measurement of the VVIQ. As these have not yet been subjected to research linking them to cognitive response variables it is not possible to establish which factor/s may be of relevance.

The Control of Visual Imagery

Theoretically the ability to control mental images seems to have a paradoxical association with creative thinking (Richardson, 1969). It could be speculated that autonomous imagery allows for the generation of new ways of representing and thinking about a problem. Alternatively, it may be assumed that the ability to control an image would be crucial in the development of new ideas. This paradox is briefly discussed below.

The notion that autonomous imagery is useful for the generation of creative ideas has the greatest anecdotal and theoretical support in the literature. It receives support from the anecdotal literature both in the association between creativity and psychopathology (see Barron, 1990; Eysenck, 1995; and, Post, 1994) and through studies of the association between autonomous imagery and psychopathology (e.g. Gordon, 1950). Furthermore, autonomous imagery is prevalent in the forms of mental imagery most commonly associated with creativity (McKellar, 1957) and notable in the representational

redescriptions of Coleridge, Dali, Edison, Kekule, and others (e.g. Ghiselin, 1952. Mavromatis, 1987, and Rothenberg, 1995). Complementary to these accounts is the psychodynamic perspective which focuses upon the emergence of unconstrained and uncritical ideation in primary process thinking (e.g. Suler, 1980). Finally, a study by Khatena (1975) found that autonomous imagers had higher scores on a creative self-perception scale (Khatena, 1975).

Alternatively it could be argued that the control of mental imagery could facilitate the use of mental imagery in creativity. This claim is based upon the notion that autonomous mental imagery may inhibit logical thought processes. This argument derives from a commonly held assumption that arbitrary ideas emerge and are value tested (e.g. Boden, 1990; and, Johnson-Laird, 1993). It receives tentative anecdotal support in the reports of Einstein and others who claim to have had much control of their mental images (Shepard, 1978a).

The meta-analytic review supported the interpretation that there is a positive association between control of mental imagery and creativity. Forisha (1981) found an association between the amount of self-reported control of mental imagery and performance on a divergent thinking task. Likewise, though Parrott and Strongman (1985) and Shaw and DeMers (1986) did not find as many significant associations their data consistently reported associations in this particular direction. These results may be a consequence of the context in which the creativity task is performed (the standard test room format) which would favour controlled mental imagery.

Finally, it should be noted that all of the studies reviewed in the meta-analysis treated the control measure of mental imagery as a continuous variable. In contrast the analyses from the previous study showed that the only realistic way of employing the TVIC is to treat it as a trichotomous variable. As this finding questions the validity of the results presented in the meta-analysis the hypothesis that there is a positive association between the control of mental imagery and divergent thinking is less secure.

Having reviewed the hypothesised relationship between the measures used in the present study two hypotheses can be made. The first of these is that there will be a straight-forward linear association between the vividness of mental imagery and performance on the divergent thinking tasks. The effects of self-reported control of mental imagery are less clear-cut. According to the review undertaken two diametrically opposed

hypotheses could be put forward. The first of these posits a role for unconstrained imagery and the second argues that manipulation, synthesis, and transformation all require a highly constrained imagery. Although the meta-analysis supports the latter interpretation the problems found with the measure of control used by researchers suggests that a two-tailed interpretation is required.

Method

Participants. Sixty-two females and twenty-eight males studying psychology at Middlesex University took part in the study. The age of the participants ranged from eighteen to forty-three with a median age of twenty-one and a mode of nineteen.

Design. In keeping with the previous research into the role of mental imagery in creative thinking the study employed a simple correlational design in which participants' scores on the three eyes-open VVIQ factors were correlated with their scores on the divergent thinking tasks. Here all hypotheses were one-tailed with the prediction that the higher the self-reported vividness of mental imagery the better the performance on the divergent thinking tasks. Provided the appropriate psychometric properties are present, no quartile-split analyses will be conducted.

An independent groups design was used to investigate the role of control of imagery in divergent thinking performance. Participants were assigned to one of three quasi-experimental groups on the basis of their scores on the TVIC (high autonomy = 18 or less; low autonomy = 18 to 23; and controlled imagery = 24). Divisions were based upon the larger sample analysis derived from the previous research. The dependent variables were the six sub-measures of divergent thinking as 'blind' rated by two judges.

Materials. The same versions of the VVIQ and TVIC as those used in the factor analytic studies were employed. Further details can be derived from the two studies previously conducted.

The TTCT Parallel Lines task (PL) was developed by Torrance (1974) as part of a battery of figural creativity tasks. The aim of the task is to produce as many pictures as possible using parallel lines as the main structure of the picture. The shortened version of the task takes 5 minutes to administer. The PL task is then scored by two judges on the basis of fluency, flexibility, and originality. If an inter-rater reliability coefficient greater

than $r=0.7$ is found then the scores are collapsed and three performance sub-measures of fluency, flexibility, and originality are derived.

The TTCT Unusual Uses task (UU) was developed by Torrance (1974) as part of a battery of verbal creativity tasks. The aim of the task is to produce as many uses for a specified object (e.g. a cardboard box) as possible. Further details are identical to those given for the PL task.

Procedure. Participants volunteered for the study through internal advertisement. Once they had agreed to take part in the study the participants were tested individually in small cubicles. In all cases the participants were initially required to complete the VVIQ and TVIC. When they had completed the questionnaires they were asked to perform the two TTCT tasks. Once all of the data had been collected the divergent thinking scores were blind marked by two judges on the basis of the scoring guide provided by Torrance (1974). Inter-rater reliability coefficients for all of the sub-measures exceeded the recommended 0.7 criterion. Subsequently, the scores were collated and six composite measures of divergent thinking obtained.

Results

Analyses of age and sex differences were carried out for the imagery and divergent thinking measures. Chi-square analyses showed no significant differences for the three TVIC groups for sex ($\chi^2(1)=0.08$, $p>0.05$) and age ($\chi^2(2)=2.41$, $p>0.05$). There was also a non-significant differences between males and females on their scores on the VVIQ ($t(88)=-0.26$, $p>0.05$) and a non-significant association between the VVIQ and age ($r_s(85)=-0.15$, $P>0.05$). An expected significant association was found between the VVIQ and the TVIC ($r_s(88)=0.43$, $p<0.01$). Evaluations of sex and age differences in the three VVIQ factors and the divergent thinking measures also revealed no significant effects.

The collapsed scores for the sub-measures of the figural and verbal divergent thinking tasks (see Table 5.4) show that the participants were able to perform the two tasks reasonably well. They produced more responses on the verbal task (The Unusual Uses Task) but showed a greater originality on the figural task (The Parallel Lines Task).

Table 5.4. Mean and Standard Deviation Values (in Brackets) for the Sub-Measures of the Two Divergent Thinking Tasks By self-reported Control of Mental Imagery (n=90)

DT Tasks	High 'A' (n=25)	Low 'A' (n=224)	'Controlled' (n=37)	Total
The Parallel Lines Task				
Fluency	8.28(3.71)	7.13(2.77)	7.00(3.27)	7.46(3.23)
Flexibility	6.88(3.56)	6.29(2.42)	6.49(2.70)	6.58(2.83)
Originality	11.80(7.45)	9.96(6.27)	9.76(6.35)	10.22(6.64)
The Unusual Uses Task				
Fluency	10.28(4.03)	10.04(4.61)	10.46(3.83)	10.22(4.04)
Flexibility	7.56(2.69)	7.33(2.93)	7.30(2.69)	7.30(2.75)
Originality	4.60(3.71)	3.96(3.51)	2.95(1.82)	3.90(3.17)

Key - 'A' = Autonomous

As distributions for the VVIQ tend to be positively skewed they were screened for skew and kurtosis. This showed that two of the three factor groupings yielded a significant positive skew. Given the problems of using skewed data sets in correlational studies a square root transformation of the three factors was carried out. This resulted in non-significant skews for all three factors. As these transformations did not alter the findings in subsequent correlational analyses they are presented in brackets throughout the results section.

The Eyes-Open Vividness of Visual Imagery Questionnaire

Results of a multiple correlational analysis showed a consistent association between the eyes-open VVIQ factor scores and the DT scores (see Table 5.5). However, only four of the eighteen correlations were significant and these were not specific to any sub-measure of divergent thinking. Nevertheless the correlations are within the range of findings from previous research in both mean effect size (Fisher's $r = 0.13$) and the direction of the correlations as assessed through a z approximation of the binomial distribution ($z=4.25$, $p < 0.001$).

Table 5.5. A Multiple Correlational Analysis of the Self-report Eyes-Open VVIQ Factors and The Sub-Measures of Figural and Verbal Divergent Thinking (n=90)

DT Tasks	‘Nature’	‘Person’	‘Shop’
The Parallel Lines Task			
Fluency	-0.15 (-0.16)	-0.16 (-0.17)	-0.18* (-0.19*)
Flexibility	-0.13 (-0.14)	-0.15 (-0.16)	-0.12 (-0.13)
Originality	-0.06 (-0.07)	-0.03 (-0.04)	-0.20* (-0.21)
The Unusual Uses Task			
Fluency	-0.15 (-0.15)	-0.08 (-0.08)	-0.20* (-0.19*)
Flexibility	-0.10 (-0.10)	-0.05 (-0.05)	-0.10 (-0.10)
Originality	-0.21* (-0.23*)	-0.12 (-0.12)	-0.11 (-0.11)

*p < 0.05 (one-tailed)

As transformations of the VVIQ scores resulted in non-significant skew and kurtosis for all three of the factors Kihlstrom *et al.*’s (1991) quartile split recommendation was not implemented. This is based upon the assumption that provided the parametric properties of the measures are met the issue of co-linearity (as defined by the accumulation of Fisher r values) supersedes concerns over response leniency. Overall, the results from the present research show that the self-reported vividness of mental imagery is minimally associated with the two measures of divergent thinking employed.

The Test of Visual Imagery Control

To assess whether participants with controlled imagery performed better or worse than those with either ‘low’ or ‘high’ autonomous imagery six independent groups ANOVAs were conducted. These are presented in Table 5.6 with their transformed Fisher r values (Rosenthal, 1991).

Analyses of the differences between the three levels of self-reported control of mental imagery failed to produce any significant results. An examination of the means for the three groups showed that the general trend on the six sub-measures was toward a greater performance in those scoring low on the TVIC (autonomous imagers). The total Fisher’s r value (as defined by the meta-analytic study) into the control of mental imagery and creativity is -0.10.

Table 5.6. Reported F-tests and computed Fisher's r Coefficients For the TVIC Groups on the Six TTCT Sub-Measures

DT Task	F-test (2,85)	Fisher's r
Parallel Lines Task		
Fluency	F=1.20, MSe=10.69	-0.01
Flexibility	F=0.26, MSe=8.39	-0.02
Originality	F=0.78, MSe=44.43	0.10
Unusual Uses Task		
Fluency	F=0.04, MSe=16.96	0.07
Flexibility	F=0.17, MSe=7.97	0.29
Originality	F=1.82, MSe=9.30	0.15

Discussion

An initial screening of the data showed good inter-rater reliability for the DT measures. Consequently, the scores from the two judges were combined and averages computed for the six DT measures. Following separate analyses for the two self-report measures it was found that there was a small (but consistent) association between mental imagery and divergent thinking. The weighted Fisher's r coefficients are smaller than those found by previous researchers.

Analyses of the hypothesis that there would be an association between the three eyes-open VVIQ factor scores and the six divergent thinking measures followed the conventional correlational format. Results from the study showed significant correlation coefficients in four of the eighteen tests. When combined the Fisher's r revealed a small association. Although these results do not suggest a major role for the vividness of visual imagery in divergent thinking they do reveal an element of consistency as all of the coefficients were in the predicted direction.

As the second study found that the TVIC was not a continuous variable, three groups of Imagers were derived from the scale and significance tests were computed using six independent groups AVOVAs. At the beginning of this study two opposing hypotheses were put forward to explain a possible link between the control of mental imagery and divergent thinking performance. While no firm conclusions can be drawn as

non-significant findings were reported, the trend was toward better performance in the autonomous imagery group. This finding contrasts with those found in previous research which treated the TVIC as a continuous variable (e.g. Forisha, 1981).

In examining why the present study failed to produce the 'marginal' effect size drawn from the meta-analysis several methodological reasons emerge. The first of these relates to the self-report measures employed; the problems with the TVIC have already been explained so will not be addressed further. It could be argued that the use of the eyes-open version of the VVIQ did not allow the participants to fully express their vividness of mental imagery (Marks, 1995). While this is a valid point it does not explain the reduction in effect size because several of the studies employed in the meta-analysis also used an eyes-open version of the VVIQ (e.g. Shaw and Belmore, 1982-83). Furthermore, it is sensible to use a measure of mental imagery that matches the mode of operation used to complete the divergent thinking measures.

An alternative methodological critique of the present study concerns the use of shortened versions of the divergent thinking tasks. As previous research has shown that the use of mental imagery in cognitive tasks requires a greater amount of elaboration (Denis, 1982) a shortened version of the divergent thinking tasks may have inhibited the use of mental imagery. This issue, addressed in the fifth study, is important but does not explain why the effect size is smaller in the present study as several studies employed similar tasks in the meta-analysis (e.g. Shaw and DeMers, 1986).

One issue became apparent through the observation of the two self-report measure scores. If the nature of the two measures is considered then it is evident that the VVIQ plays a secondary role as a test of the ability to produce a mental image; in that responding with a five to any image is a statement of the individual's inability to produce an image. The TVIC, however, does not provide this information because people can have a low score for two reasons, either because they cannot manipulate their imagery or because they do not have any imagery. As the VVIQ scores tend to be correlated with the TVIC scores (a Spearman's rank correlation coefficient of 0.43 was found in the present study), it must be concluded that at least some of those people who report being unable to control their imagery fail to do so because they have no imagery for the particular item. However, there are also a sizeable proportion of people who report vivid imagery but no imagery control (31% in the present study). In essence the autonomous imagery groups

might be reporting truly autonomous imagery or they might be reporting no imagery. This problem is of vital importance to any study of the criterion validity of the TVIC and further reinforces the claim made in the previous study that a new measure of the self-reported control of mental imagery needs to be developed.

In summary inspection of the results from this study do not provide any compelling evidence for the usefulness of the vividness of visual imagery in creativity, at least, not under the conditions of measurement employed here. The total Fisher's r shows that the measures accounted for less than 2% of the variance in the data set. However, these findings are very much in the mould of previous research using the VVIQ and TTCT (e.g. Shaw and DeMers, 1986). The main conclusion is that researching the vividness of mental imagery and creativity requires a better consideration of the variables under investigation. At present the effect size is so small that research is driven by power and sample size requirements.

The coefficients derived from the eyes-open vividness scores were small and conformed to the findings of the meta-analysis. The imagery control measure, however, produced the opposite findings to those reported in the meta-analysis. If this is a consequence of the way in which the control measure is treated, then it shows a lack of linearity. If it is because of the paradoxical status of imagery control in creativity, then it reinforces the need to develop a measure of imagery control that can differentiate the usefulness of control and autonomy.

Study Five. The Construct Validity and Reliability of the Vividness of Poetry Imagery Questionnaire (VPIQ).

Introduction

The research presented so far in this chapter has used two of the standard imagery questionnaires to investigate individual differences in imagery ability. In light of the failure to show anything more than a small but consistent association between self-reported mental imagery and divergent thinking, the following studies aimed to develop a measure that is related to both imagery and creativity.

Although the VVIQ and the TVIC have been used to measure a wide range of subjective and objective measures of cognitive ability (see McKelvie, 1995, Marks, 1995; and, White *et al.*, 1977), recent research has started to tailor mental imagery self-report measures to specific contexts (e.g. O'Bryan-Doheny, 1993). Ahsen (1985, 1990, 1993), for example, has taken the basic VVIQ format and applied a 'parental filter' to assist his understanding of the dynamic nature of mental imagery. Marks and Isaac have developed the Vividness of Movement Imagery Questionnaire (Isaac, Russell, and Marks, 1986) to assess individual differences in perceptual motor skills (e.g. Isaac and Marks, 1990, 1994). Given the small associations derived from the imagery and creativity research so far the same principle may prove fruitful.

The initial question, however, is upon what basis should a questionnaire be developed? A questionnaire that provides examples of the use of imagery in creativity would be useful but, as there are so many circumstances and ways of generating creative ideas, this would not be feasible (Hanard, 1997; Hocevar and Bachelor, 1989; McGuire, 1997). The alternative procedure is to design an instrument that measures a facet of mental imagery that is particularly relevant to creativity. The aim of the following studies is to develop and assess an imagery questionnaire with stimulus attributes that are related to both imagery and creativity. The area selected is creative writing which provides a wealth of imagery-linked literature (Barron, 1988; Fleckenstein, 1992; Jennings, 1991; Spender, 1952).

In considering the sources of literature that may be employed as a means of assessing the vividness of figurative literature, it is necessary to consider the circumstances in which imagination imagery is both employed and evoked. There are many forms of literature that encourage its use and evocation. However, the literature suggests that mental imagery is most frequently employed in short prose as a device to cultivate creativity (Fleckenstein, 1992) and to reinforce emotional responses (Jennings, 1991). Anecdotal reports suggest that a great number of poets use mental imagery as a special form of symbolism (Paivio, 1983) and the number of poets reporting the use of imagery in creativity exceeds that of any other literary grouping (e.g. Baudelaire, Blake, Coleridge, Spender, and Yeats).

Imagery has long been an important ingredient of poetry and is represented very strongly in many styles. For example, the use of Kennings (e.g. *ring-giver* for king) in

both Old English and modern Poetry yield particularly evocative forms of imagery. Consider, for example, the richness of mental imagery in John Updike's play upon the use of the Kenning in his poem "Winter Ocean":

Many-maned, scud-thumper, tub
of male whales, maker of worn wood, shrub-
ruster, sky mocker, rave!
portly pusher of waves, wind-slave.

(John Updike, 1960, Taken from Miller and Greenberg, 1981)

Other devices used in poetry which are rich in figurative language include synaesthetic prose (e.g. "The yellow fog that rubs its back upon the window-panes"; T.S.Elliot), similes (e.g. "For hope grew round me, like the twining vine, and fruits, and foliage, not my own, seemed mine"; S.T.Coleridge), metaphors ("Come, fill the cup, and in the fire of spring your winter garment of repentance fling"; E.Fitzgerald), a synecdoche in which a part (e.g. hand) is used to define the whole ("The hand that sways the king beguiles the state"; W.Shakespeare), an apostrophe in which a person or thing is addressed ("With how sad steps, O moon, thou climb'st the sky"; Sir P.Sidney) and, in the use of two opposing meanings to create a new meaning (an Oxymoron) such as W.B.Yeats reference to the new Republic of Ireland as, "A terrible beauty is born" (all cited by Miller and Greenberg, 1981).

Though lacking empirical support there is a considerable amount of anecdotal evidence that imagery is an important ingredient in certain forms of poetry. The devices used in poetry could be dependent upon imagery in both their development and the force of their expression. Consider, for example, Murray's review of Peter Redgrove's poetry anthology:

"In dreamlike or visionary poems such as the "Poems of Parasyn", the poems ride on glittering wings of vivid imagery wasps on fallen apples "thick as cobbles" are seen to "mine deep and invisible their galleries of fruit". (Murray, 1994, p.23).

So how can figurative poetry be understood in the context of conventional mental imagery research? Although there has been a considerable amount of research into the

effects of imageability on cognitive processes it has focused upon paired stimuli learning or text processing and memory (Benjafield, 1987; Denis, 1982; Marschark and Hunt, 1989; Paivio, 1971; Paivio, Yuille and Madigan, 1968). The effects of the imageability of figurative poetry have received scant attention despite their obvious appeal to 'learned' and thespian pursuits and the implicit association with mnemonic strategies. Indeed poetry receives barely a mention in the mental imagery literature and it is only when broad searches are undertaken that imagery emerges in literary reviews (e.g. Alvarez, 1994; Bull, 1995; Leighton, 1996; and, Murray, 1994). This is unfortunate as a wealth of 'stimuli' awaits investigation.

An additional advantage with using poetry as the stimuli for the rating scale is that these are in essence qualified products of the creative process. As there is a large theoretical and empirical body of research into aesthetic preference and creativity (Eysenck, 1995) a measure of the vividness of imagination imagery may also be indirectly accessing the preference for complex and artistic imagery that has been linked with creativity (Kuzendorf, 1982; Lindauer, 1977; Sobel and Rothenberg, 1980).

The aim of the present study is to develop a self-report measure of the vividness of visual imagery that uses a particular creative product which is thought to be associated with the use of mental imagery in both its development and aesthetic appeal. To achieve this it is necessary to select extracts of figurative poetry that use devices that evoke mental imagery. These can then be presented to participants in a format that is very similar to the VVIQ. However, before a measure can be used to assess a proposed relationship between mental imagery and creativity it is necessary to understand its construct validity and internal reliability.

Method

Participants. One-hundred and ninety-four psychology undergraduates from Middlesex University completed a measure of the vividness of figurative poetry imagery. Analyses of age and sex are included in the results.

Materials. The questionnaire was developed in the same format as Marks' VVIQ (Marks, 1972, 1973). Vividness ratings ranged from 1 ("Perfectly clear and vivid") to 5 ("No image at all, you only "know" that you are thinking of an object"). Sixteen items were presented in four blocks, derived from four extracts of figurative poetry. The first of

these was a full version of Nikki Giovanni's "Winter Poem", the second was an extract from Robert Herrick's "To the Virgins, to Make Much of Time", the third was an extract from T.S.Elliot's, "The Love Song of J.Alfred Prufrock" and the fourth was an extract from Richard Crashaw's "An Epitaph upon a Young Married Couple Dead and Buried Together". All of the samples were selected from Miller and Greenberg (1981). The questionnaire items are presented in Table 5.7.

Procedure. The questionnaire was given to the participants for self-completion at a time when they felt comfortable. The participants were informed prior to completing the questionnaire that they should complete the task on their own. They were also informed that they should complete the questionnaire as quietly, quickly, and honestly as possible. The questionnaire takes approximately fifteen minutes to complete.

In order to complete the vividness ratings the participants are required to read each passage twice. In the first reading they are asked to read the extract in full and simply construct imagery associated with it. This is followed by a second reading in which the elements of the poem are broken down and imagery ratings are made for each item (see Table 5.7).

Statistical Procedures. Following screening for univariate and multivariate normality the internal construct of the VPIQ was assessed through a Factor Analysis (the Alpha Factoring technique), followed by oblique rotation using oblimin. Internal consistency of the factors was assessed using Chronbach's alpha.

Results

One-hundred and ninety-four participants (125 females and 68 males) with a median age of 23 (ranging from 18 to 48) took part in the study. Combined scores for the sixteen items did not correlate with age ($r(192) = -0.05$, $p > 0.05$) and a non-significant difference between males and females was observed ($t(191) = 1.39$, $p > 0.05$). The VPIQ, presented in the same format as the VVIQ produced an overall item average of 2.36 with items ranging from 1.66 for item one ("a snowflake falling on your brow") to 3.35 for item six ("old time flying"). An assessment of response bias yielded a significant result ($t(193) = -13.31$, $p < 0.001$) similar to that found for the VVIQ in Study Two. Screening for skewness and kurtosis (see Study One for procedural details) resulted in four square-root (Items 5,8,15, and 16) and two logarithmic (Items 1 and 13) transformations.

As previous factor analyses presented in this chapter utilised a straight-forward Principal Components Analysis (PCA) the same procedure was adopted in the present study. However, as no sensible interpretations could be derived from a PCA a Factor Analysis (FA) was conducted. All the results reported are produced from the less conventional, but equally applicable, Alpha Factoring technique.

Table 5.7. Representation of the Primary Item loadings following an Oblique Rotation (loadings of less than 0.4 are suppressed) on the Sixteen VPIQ Items (n=194)

Item	Contemporary Poetry	Traditional Epitaphic	Traditional Metamorphic
A snowflake falling on to your brow	0.66		
A web of snow engulfing you	0.46		
Squeezing snow into spring rain	0.46		
Turning into a flower	0.49		
Gathering rosebuds			0.51
Old time flying			0.55
A flower smiling			0.75
A flower dying			0.56
Mermaids riding seaward on the waves	0.70		
Combing the white hair of the waves	0.68		
Seagirls wreathed with seaweed red and brown	0.63		
Being woken to drown	0.50		
Dead		0.82	
Lying under a sheet of lead		0.65	
Sleeping through the stormy night		0.72	
Waking into a light		0.53	

The Scree Plot and eigenvalues produced one or four factor solutions. As the four factor solution accounted for the most variance in the data set it was further analysed. This solution accounted for 57.9% of the variance in the data set. When the item loadings were suppressed at 0.4, however, none of the items loaded on the third factor. Consequently,

the third factor was removed and all further analyses were conducted on the remaining three factors.

The first factor ('Contemporary Poetry') accounted for 34.4% of the variance and loaded above 0.4 on eleven items. As three of these items loaded greater on the other factors only the interpretable eight items (derived from the first and third blocks) were selected for reliability analyses. A Chronbach's Alpha on the items revealed sufficient internal reliability (0.77) with all of the items contributing to the internal consistency of the factor (see Appendix 5.8).

The second factor ('Traditional Epitaphic') accounted for 9.3% of the variance in the data set with six items loading above 0.4. As two of these items had greater loadings on other factors they were not selected for further analyses. The primary loadings were all derived from the fourth block. A Chronbach's Alpha analysis was satisfactory (0.75) with all of the items contributing to the internal reliability of the measure (see Appendix 5.9).

The final factor ('Traditional Metamorphic') accounted for 6.8% of the variance with four items, pertaining to the Robert Herrick poem, loading primarily on this factor. Reliability analysis using Chronbach's Alpha met the minimal standard (Alpha = 0.69) with all of the items contributing to the internal reliability of the measure (see Appendix 5.10).

Table 5.8. Descriptive Statistics for weighted Item average scores on the three factors derived from the VPIQ (n=194).

Factor	Mean	St. Dev.	Q1	Q4
Contemporary Poetry	2.49	0.73	2.00	3.00
Traditional Epitaphic	2.02	0.86	1.25	2.75
Traditional Metamorphic	2.37	0.86	1.75	2.94

Following the Factor and reliability analyses mean and quartile scores were derived for the three factors by simple addition and weighted division. These showed that the second factor ('Traditional Epitaphic') produced the highest vividness ratings and the first factor ('Contemporary Poetry') the least vivid imagery. A repeated measures

ANOVA confirmed that the three factors produced significantly different responses to justify their separate use in further analyses ($F(2,382)=33.94$, $MSe = 0.34$, $p < 0.001$).

Discussion

The aim of the study was to evaluate the construct nature and internal reliability of a self-report measure of vividness of mental imagery that utilised novel and aesthetic images from poetry. Initial screening of the measure showed similar vividness ratings to those observed for the eyes-open VVIQ. As expected a response leniency was found with participants reporting a greater amount of vividness than non-vividness for the items. It is therefore recommended that criterion studies should carry out transformation procedures to smooth the effects of skewness.

Whilst the VPIQ differs in the content of imagery its design was constructed to map the format of Marks' eyes-open VVIQ. It was important to maintain the meaningfulness of the block format and essential that a five-point scale (enabling a 'no image' response) was employed. Although initial problems of factor analytic interpretation were found it was eventually possible to derive a solution that was comparable to that found in the eyes-open VVIQ analysis. Though four factors were derived from the factor analysis one of these failed to load on any of the items. The three remaining factors met the minimal standards for internal reliability and were shown to differ enough from each other to warrant their combined use in future research.

While this measure is not quite as easy to characterise as Marks' eyes-open VVIQ, it does have the same multivariate characteristics suggesting the use of its three factors as continuous variables. Furthermore, given that it is a vividness measure its relationship with cognitive performance measures can be readily hypothesised. In summary, a measure of aesthetic imagery has been developed and assessed for internal validity and reliability. Although the findings are less satisfactory than those found for the more generic eyes-open VVIQ, it demonstrates sufficient validity and reliability to be used as a predictor of creativity.

Study Six. A Criterion Study of the VPIQ and Two Torrance Tests of Divergent Thinking

Introduction

The aim of this study was to assess the relationship between the three VPIQ factors and the six sub-measures of divergent thinking employed in the previous study of criterion validity. As this is a new measure of the self-reported vividness of mental imagery, hypotheses about which factor is most relevant cannot be made. However, it is predicted (and hoped) that the overall association between the VPIQ and the divergent thinking measures will be stronger than that found with previous self-report measures.

The discussion in Study Three suggested that the observed associations between the self-report imagery measures and the two divergent thinking measures may have been smaller than those previously found because a shortened version of the divergent thinking tasks was used. The use of mental imagery in creativity could require a greater amount of elaboration of the stimulus materials resulting in longer latency requirements. As this effect has been shown in previous cognitive performance studies investigating the role of the vividness of mental imagery (Denis, 1982), both the shortened and the standard form tasks were used in the present study.

Method

Participants. Sixty-eight females and twenty-four males studying psychology at Middlesex University took part in the study. However, the data for one participant on the Parallel Lines part of the TTCT was lost. The age of the participants ranged from eighteen to fifty-two with a median age of twenty-four.

Design. A simple correlational design was employed where the participants' self-report scores on the three VPIQ factors were correlated with their scores on the six sub-measures of divergent thinking derived from the two divergent thinking tasks by each version of the TTCT. All hypotheses were one-tailed with the prediction that vividness will be positively correlated with performance. Where necessary univariate transformations were performed and presented.

Materials and Procedure. The VPIQ was presented in a test-room format to small groups of participants (1-4). Details of the VPIQ were presented in the previous study.

The Parallel Lines Task and the Unusual Uses Task were presented in the standard and shortened formats. Details are given above. The same procedure was applied as that given in the Study Three.

Results

Like the VVIQ the factors derived from the VPIQ tend to be positively skewed. Initial screening of the three factors derived from the questionnaire showed that only the second factor was skewed and that the problem was easily rectified using a square root transformation. Inter-rater reliability coefficients for the two judges exceeded 0.7 in all cases. The collapsed scores for the sub-measures of the figural and verbal divergent thinking tasks show that the participants' shortened form scores were comparable with those found in the previous study (see Table 5.8).

Table 5.8. Basic Descriptive Statistics For the Sub-Measures of the Two Divergent Thinking Tasks.

Divergent Thinking Measure	Shortened form (n=44)		Standard form (n=48)	
	Mean	St. Dev.	Mean	St. Dev.
The Parallel Lines Task				
Fluency	9.87	4.32	14.77	5.08
Flexibility	8.29	3.40	11.67	3.36
Originality	13.41	6.88	21.85	8.95
The Unusual Uses Task				
Fluency	10.20	4.18	15.10	4.92
Flexibility	7.31	2.51	9.01	2.94
Originality	5.57	3.47	8.51	4.40

Results for the multiple correlational analysis are presented in Table 5.9 for both the shortened and standard versions of the divergent thinking tasks. Overall Fisher's r values for the two versions were 0.13 for the shortened version and .11 for the standard form. As the participants' performed comparably on the two versions the scores were analysed using partial correlations. These are also presented in Table 5.9.

The overall findings from this study are very similar to those found in the study of the eyes-open version of the VVIQ. The direction of the associations was consistent but the strength of association was small in all cases. Of the eighteen associations derived from the partial correlations four were significant. Observation of the findings shows that the VPIQ factors were more likely to be associated with the verbal measure of divergent thinking. Overall the combined scores produced a total Fisher's r coefficient value of 0.12.

Table 5.9. Multiple Correlations for the Shortened, Standard and Combined forms (Where the factor Time is Partialled out of the Correlation) of the TTCT with the VPIQ

DT Task	Shortened form (n=44)			Standard form (n=48)			Combined (n=92)		
	F1	F2	F3	F1	F2	F3	F1	F2	F3
PL Task									
Fluency	-0.05	-0.17	-0.05	-0.01	-0.05	-0.22	-0.01	-0.10	-0.15
Flexibility	-0.00	-0.07	-0.01	-0.01	-0.08	-0.21	-0.01	-0.07	-0.13
Originality	-0.14	-0.22	-0.10	-0.05	-0.29*	-0.15	-0.08	-0.26**	-0.13
UU Task									
Fluency	-0.24	-0.34*	-0.05	-0.05	-0.00	-0.19	-0.13	-0.17	-0.13
Flexibility	-0.22	-0.33*	-0.13	-0.18	-0.08	-0.11	-0.20*	-0.21*	-0.11
Originality	-0.20	-0.24	-0.21	-0.09	-0.16	-0.02	-0.14	-0.20*	-0.07

(F1: Contemporary Poetry; F2: Traditional Epitaphic; F3: Traditional Metamorphic)

*p<0.05 **p<0.01 (one-tailed)

Discussion

Initial tests for inter-rater reliability and univariate normality showed that a correlational design was acceptable. Consequently, the self-report measures were correlated with the six sub-measures of divergent thinking assessed by the two versions presented. The overall findings from these two groups were very similar. While consistent small associations were found, neither of the creativity tests showed a particular pattern of association that could be explained in terms of mental imagery differences. As the findings were similar the scores were combined and partial correlations performed.

Overall the findings are very similar to those produced in the previous study with the VVIQ.

As Study Three used shortened versions of the TTCT, the findings were open to the interpretation that the smaller associations found were the product of time limitation in task performance. To assess this possibility the present study compared the associations from both the shortened and standard versions of the task. Although no statistical analyses were carried out, it was evident from an observation of the overall Fisher's r values that the association between self-reported mental imagery and creativity did not improve as the amount of time to perform the task increased. Consequently, the scores for the two versions were analysed using a partial correlation technique. The final Fisher's r coefficient did not reach the 'marginally acceptable' criterion used by McKelvie (1995) to assess the usefulness of mental imagery measures in predicting behavioural performance.

As was true of the previous study into the relationship between mental imagery and divergent thinking it was predicted that there would be a consistent association between the factors representing the vividness of mental imagery and the sub-measures of divergent thinking. As the content of the present self-report task was drawn from a creative source it was hypothesised that a stronger association would be found. However analyses of the combined scores found similar associations to those reported in previous studies. The full implications for future research into the individual differences approach are discussed in the next chapter.

General Discussion

The initial aim of the present chapter was to empirically evaluate the self-report measures of mental imagery used in individual difference studies of the role of mental imagery in creativity. Following these analyses of construct validity and internal reliability the measures were assessed in a correlational study of self-reported mental imagery and creativity. The overall conclusion drawn from these studies is that in groups of university students the self-reported vividness of mental imagery is minimally associated with performance on divergent thinking tasks.

The meta-analytic review carried out in Chapter Four showed that the most commonly used self-report measures of mental imagery employed in individual difference studies of the role of mental imagery in creativity are the VVIQ and TVIC. Although

these studies consistently report a small association between mental imagery and creativity, an overview of the findings revealed several contradictions in the research. Consequently, it was decided that an initial inquiry into the individual differences approach required a thorough examination of the variables under review and that this necessitates an assessment of the construct nature and internal reliability of the self-report measures of mental imagery.

The first study reported in this chapter suggested that the Marks' eyes-open VVIQ has good parametric properties. However, the PCA suggested that the eyes-open version could be interpreted either as a one or three factor measure of the vividness of visual imagery. Although previous research into the VVIQ and divergent thinking performance used a total scoring procedure, the alternative three factor solution was adopted in the present chapter because it accounted for more variance in the questionnaire and the factors produced demonstrably different responses. However, the association between imagery and creativity was still weak and the ambiguity of the findings meant that this was one of two possible ways of assessing the respondents' scores on the VVIQ. Therefore these findings do not question the validity of previous studies so much as offer a fruitful alternative way of studying vividness of mental imagery and divergent thinking.

Whilst the findings from the first study produced some support for the scoring procedures used in the previous research with the VVIQ, the results from the second study questioned the TVIC scoring procedures adopted by previous researchers. The aim of this study was to assess the TVIC using the same procedures adopted in the previous study. However, univariate screening for skew and kurtosis showed that this measure should not be used as a continuous variable. These results questioned the validity of previous research into the role of the control of mental imagery and divergent thinking (Forisha, 1981; Parrott and Strongman, 1985; and Shaw and DeMers, 1986).

The third study investigated the relationship between the vividness and control of imagery and measures of figural and verbal divergent thinking. The Torrance measures of divergent thinking were selected because they were the most frequently employed tests in the previous individual difference research (Campos and Perez, 1989; Forisha, 1981; Parrott and Strongman, 1985; Shaw and Belmore, 1982-83; and, Shaw and DeMers, 1986). The results from the study showed a small but consistent relationship between self-reported vividness of mental imagery and divergent thinking performance. However, the

findings from the self-report control of imagery measure failed to show significant differences between the groups and any identifiable trend emerged in the opposite direction to the previous research findings (Forisha, 1981; Parrott and Strongman, 1985; and Shaw and DeMers, 1986). These findings may have arisen from a necessarily different scoring procedure.

Although the vividness measure of mental imagery was consistently associated with the divergent thinking measures, the relationship was small. It was hypothesised that the strength of the association may be increased if vividness was tailored to creativity and so the VPIQ was developed. Its construct nature and internal reliability was assessed in the fourth study. The results from this study fell somewhere between those of the first and second studies. The VPIQ had reasonable parametric properties but it did not yield as good psychometric properties as the VVIQ. However, it was possible to interpret a three factor solution which accounted for almost 60% of the variance in the data set. Furthermore the items on these factors produced significantly different responses.

The final study carried out in the present chapter assessed the relationship between the three factors derived from the VPIQ and the sub-measures of divergent thinking in two test-format procedures. As the shortened and standard forms of divergent thinking did not differ in their association with the VPIQ, partial correlation analyses were performed. The findings from this study again showed a consistent relationship between the vividness measure and the divergent thinking scores. However, the use of a context-specific vividness measure did not result in a stronger association between vividness and creativity scores.

In conclusion, the findings from the present study add further data to the individual differences approach on the association between mental imagery and creativity. The three studies into the construct validity and internal reliability of the self-report measures of mental imagery show that the eyes open version of the VVIQ can be treated as a three factor questionnaire. They also show that A.Richardson's (1969) version of the TVIC should not be used as a continuous variable and that it is possible to develop a context-specific measure of the vividness of visual imagery. However, although the two measures of vividness yield consistent associations with divergent thinking performance, these associations are small. Furthermore, the control of imagery measure does not predict

performance on divergent thinking tasks. These results are discussed in further detail in the following chapter where a revised meta-analysis is carried out.

Chapter VI

Study Seven. A Revised Meta-Analysis in the light of the Findings from the Present Research

Introduction

At the beginning of Chapter Four, it was argued that there are two predominant research protocols in the study of mental imagery and creativity. The first of these, identified as the individual differences approach, has seen a steady accumulation of research over the past twenty-five years. The alternative method, referred to as the image generation approach, emerged approximately ten years ago and is discussed in detail in the following chapter. Justification for these very different methods is based on the vast number of anecdotal reports testifying to the use of mental imagery in historical creativity.

The aim of the individual differences approach appears to be the demonstration that mental imagery and creativity abilities are linearly associated. To establish this association a self-report measure of an aspect of mental imagery is correlated with a performance measure of creativity. The aim of the meta-analysis presented in Chapter Four was to collate the information from these studies and determine the nature of the association via weighted Fisher's r correlation coefficients.

Having developed a set of selection criteria to protect against methodological problems linked to both the meta-analytic procedure and the measures under review, it became apparent that many of the studies did not fulfil the basic requirements. Little conformity was found in both the findings and the use of the measures. Consequently, a further set of studies was undertaken in which the selection criteria were adhered to. These studies found that when self-reported mental imagery and creativity are assessed independently of any other variable there is only a small association between the two variables. Coupled with these studies is a further study by Gonzalez, Campos, and Perez (1997) which was not available to the author when the first meta-analysis was carried out. As this study fulfils the criteria listed in Chapter Four it has also been included in the final analysis.

The Revised Meta-Analysis

Having carried out two studies into the relationship between three mental imagery measures and two divergent thinking measures, it became possible to carry out a revised meta-analysis. With the further study conducted by Gonzalez *et al.* (1997) the three additional studies increase the total sample size by 772 participants to 1494. The full analysis is listed in Table 6.1.

The final analysis of the relationship between self-reported mental imagery and creative performance is derived from 94 tests and 1,494 participants. The overall Fisher's r value is slightly lower than that found in the previous meta-analysis and falls just below Cohen's (1992) assessment of the minimum acceptable criterion validity (for a small effect 0.18). A positive effect of the addition of these further studies, however, is a greater consistency ($\chi^2(8)=8.90$, $p>0.05$) and a stronger overall significance level ($z=5.80$, $p<0.001$). These findings therefore reinforce the existence of a relationship between mental imagery and creativity but reduce the importance of the relationship.

Table 6.1. A Revised Meta-Analysis Following the Inclusion of Three Further Studies into Self-reported Mental Imagery and Creativity

Author	Tests and Participants	Lower Bound	Mean r	Upper Bound	Probability
Bowers	1 (32)	0.17	0.54	0.72	0.003
Campos and Perez	4 (122)	0.03	0.21	0.37	0.012
Forisha*	6 (320)	0.08	0.19	0.29	<0.001
Parrott and Strongman**	14 (70)	-0.19	0.05	0.28	0.413
Shaw and Belmore	3 (67)	-0.00	0.24	0.45	0.025
Shaw and DeMers	24 (141)	0.06	0.22	0.37	0.004
Gonzalez et al.	5 (n=560)	0.02	0.10	0.18	<0.001
le Boutillier (Study Three)	24 (n=90)	-0.10	0.11	0.31	0.148
le Boutillier (Study Five)	18(n=92)	-0.09	0.12	0.32	0.125
Total	94(1494)	0.10	0.15	0.20	<0.001

* Provides a composite score

** Non-significant results were not reported so $z = 0.00$, $r = 0.00$, and $p = 0.50$ is assumed

Characteristics of Mental Imagery

As the three studies have contributed in various ways to a further understanding of mental imagery and creativity, individual meta-analytic procedures were carried out across these measures. In Chapter Four it was observed that both the vividness and control of mental imagery were significantly associated with the divergent thinking measures. However, inconsistencies, not immediate to the meta-analysis, were found when studies

that employed both measures were assessed. In the studies that followed further developments emerged and a re-evaluation was therefore deemed necessary.

Table 6.2. Fisher's r Correlation Coefficients for studies that Employed a Measure of the Vividness of Mental Imagery

Author	Participants and Tests	Lower Bound	Mean r	Upper Bound	Probability
Bowers	32 (1)	0.17	0.54	0.72	0.003
Forisha	320(3)	-0.07	0.04	0.15	0.237
Parrott & Strongman	70 (7)	-0.13	0.11	0.34	0.179
Shaw & Belmore	67(3)	-0.00	0.24	0.45	0.024
Shaw & DeMers	141(12)	0.10	0.26	0.41	0.001
leBoutillier (Study Three)	90(18)	-0.08	0.13	0.33	0.108
leBoutillier (Study Five)	92(18)	-0.08	0.12	0.31	0.124
Total	812(62)	0.07	0.14	0.22	<0.001

The vividness measure most commonly used by those researching mental imagery and creativity is Marks' VVIQ (1972, 1973). This measure was also employed in Study Three of Chapter Five and an analysis of the internal structure of the eyes-open VVIQ showed that it could be assessed as a single or content-based multi-factor measure. As the latter approach explained a much greater proportion of the variance and yielded a parsimonious solution it was adopted in Study Three. This study can be coupled with a further investigation in which a new measure of vividness (the VPIQ) was developed and assessed in the context of divergent thinking. The results from these studies and those produced by the previous researchers are presented in Table 6.2.

The two studies from the Chapter Five produced combined Fisher's r values that were very close to those observed in the first meta-analysis. Consequently, the findings from this study are very similar to those found previously. The seven studies were homogeneous ($\chi^2(6)=10.71$, $p>0.05$) and an overall Stouffer test was significant ($z=3.99$, $p<0.001$). The combined correlation coefficient was slightly lower than that found for the vividness measures in Chapter Four and falls just below McKelvie's acceptability level for criterion tests.

The inclusion of The Gonzalez *et al.* (1997) study resulted in a twofold increase in the number of participants taking part in imagery control studies. That Gonzalez *et al.* (1997), like all of the other studies, treated the control measure as a normally distributed continuous variable is worrying given the findings from Study Two in Chapter Five. As it is not possible to convert these scores the resulting meta-analysis (see Table 6.3) must be treated with caution. This is especially important as the findings from Study Three contrast with the other studies.

Table 6.3. Fisher's r Correlation Coefficients for studies Employing a Measure of The Control of Mental Imagery

Author	Participants and Tests	Lower Bound	Mean r	Upper Bound	Probability
Forisha	320(3)	0.07	0.18	0.29	<0.000
Parrott & Strongman	70 (7)	-0.18	0.06	0.29	0.307
Shaw & DeMers	141(12)	0.04	0.20	0.35	0.008
Gonzalez <i>et al.</i>	560(5)	0.02	0.10	0.18	0.010
leBoutillier (Study Three)	90(6)	-0.30	-0.10	0.11	0.839
Total	1181(35)	0.06	0.12	0.18	<0.001

The two further studies that employed the control of mental imagery resulted in a general reduction of the weighted Fisher's r from 0.17 to 0.12. The five studies were shown to yield similar findings when a chi-square analysis of heterogeneity of correlation coefficients was conducted ($\chi^2(4)=6.82$, $p>0.05$) and an overall significant test of criterion difference was observed ($z=4.12$, $p<0.001$). The final meta-analysis shows that the criterion validity of the TVIC has fallen below McKelvie's marginally acceptable threshold with less than 2% of the variance shared between the measures.

Types of Divergent Thinking

In the first meta-analysis it was found that figural divergent thinking had a marginally stronger association with the self-report measures of mental imagery than verbal divergent thinking. This was expected as the variable is very much dependent upon the stimulus attributes of the divergent thinking scores. The two measures of divergent

thinking selected for the criterion studies undertaken in the previous chapter were derived from the TTCT because they were representative of the two types of divergent thinking commonly used in this research area. The Gonzalez *at al.* (1997) study also included a figural and a verbal divergent thinking task. However, the overall analysis was performed on a combined score and an insufficient amount of information was available to compute Fisher's *r* values. Consequently, only the results from the two criterion studies presented in Chapter Five are included.

Table 6.4. Fisher's *r* Correlation Coefficients for studies Employing a Measure of Verbal Creativity

Author	Participants and Tests	Lower Bound	Mean <i>r</i>	Upper Bound	Probability
Bowers	32 (1)	0.17	0.54	0.72	0.003
Forisha	320(3)	0.08	0.19	0.29	<0.001
Parrott & Strongman	70 (7)	-0.24	0.00	0.24	0.500
Shaw & Belmore	67(2)	-0.02	0.22	0.44	0.036
Shaw & DeMers	141(12)	0.01	0.17	0.33	0.022
leBoutillier (Study Three)	90(12)	-0.16	0.05	0.25	0.318
leBoutillier (Study Five)	92(9)	-0.06	0.15	0.34	0.075
Total	630(26)	0.11	0.13	0.26	<0.001

The Fisher's *r* value for the verbal measure dropped from 0.19 to 0.13 following the inclusion of the two further studies. Much of this effect can be explained by the effects of the TVIC score in Study Five which contrasted with those of the other studies. An analysis of heterogeneity showed that the findings were comparable ($\chi^2(6)=7.44$, $p>0.05$) and an overall significant effect was observed ($z=4.84$, $p<0.001$). The revised estimate for the association between verbal divergent thinking and self-reported mental imagery was statistically inconsequential (McKelvie, 1995).

Table 6.5. Fisher's r Correlation Coefficients for studies Employing a Measure of Figural Creativity

Author	Participants and Tests	Lower Bound	Mean r	Upper Bound	Probability
Campos & Perez	122(4)	0.03	0.21	-0.37	0.010
Parrott & Strongman	70 (7)	-0.07	0.11	0.34	0.179
Shaw & Belmore	67(1)	-0.05	0.29	0.50	0.009
Shaw & DeMers	141(12)	0.10	0.26	0.41	0.001
leBoutillier (Study Three)	90(12)	-0.12	0.09	0.29	0.197
leBoutillier (Study Five)	92(9)	-0.10	0.11	0.31	0.146
Total	582(46)	0.11	0.19	0.27	<0.001

The association between self-reported mental imagery and figural divergent thinking was less severely affected by the inclusion of Studies Three and Five from Chapter Five. The studies produced homogeneous results ($\chi^2(5)=3.05$, $p>0.05$) and when combined yielded an overall significant effect ($z=4.66$, $p<0.001$). The combined Fisher's r value, although reduced from that found in the original meta-analysis, showed marginally acceptable predictive validity.

Discussion

The combined findings from this revised meta-analytic review show that self-reported mental imagery skirts between the border of inconsequential and marginally acceptable predictive validity (McKelvie, 1995). As expected, consistent small associations were found between the two variables which improved slightly when the divergent thinking tasks were presented in a figural form. The main controversy arising from these findings once again concerns the use of the TVIC as a normally distributed continuous variable. Though the overall trend from the present research is a down-sizing of the association between control and divergent thinking, the inclusion of a later study (Gonzalez *et al.*, 1997) shows that researchers are still treating this variable as though it has sufficient psychometric properties.

In this chapter data from the individual differences approach to the relationship between self-reported mental imagery and creativity have again been meta-analysed.

adding three studies employing this protocol. The overall findings, though consistent, show that this type of investigation yields only a small association between mental imagery and creativity. These results show only minimal support for the proposition that mental imagery is an important determinant of creativity and seem far removed from Shepard's (1978a) claim that creativity is a *raison d'être* for the study of mental imagery. In the following discussion an attempt is made to explain why these findings are at odds with the claims of the leading iconophiles (Finke, 1989; Paivio, 1983; and, Shepard, 1978a).

Clearly those who posit a role for mental imagery in the creative process do so for good reason. The reason that stands out is the wealth of anecdotal reports of the use of mental imagery in historical creativity (see Chapter One). In considering the evident contrast between the results from the individual differences approach and the anecdotal reports of Coleridge, Einstein, Kekulé, Poincaré and others, at least four possible explanations emerge. These are: the 'myth of genius' explanation; problems with the predictive validity of the measures used; the special imagery account; and the importance of methodological issues. Each of these is discussed and possible resolutions are put forward where relevant.

One explanation for the contrast between the current empirical and anecdotal findings pertains to the validity of the anecdotal reports of historically creative individuals. This argument, though not directly aimed at the reports of mental imagery, would explain the failure to find empirical support for imagery-based creativity in the context of retrospective embellishment. Several creativity theorists (Perkins, 1981; Schaffer, 1994; Weisberg, 1993) have investigated the claims of inspiration and insight in historically creative performance, including many moments of inspiration that involve the use of mental imagery in creativity. Weisberg (1993) has deconstructed and evaluated the anecdotal reports of Mozart, Coleridge and many others. His conclusions suggest that there are often clear antecedents to these creative discoveries that have not been given the full weight of attention by these creative individuals. These include documentary evidence that the claims of 'insight' and 'inspiration' are false. Perhaps the claims of these individuals about their extra-ordinary imagery abilities are part of the 'myth of genius' being fostered.

The aim of Weisberg's (1993) research is to demonstrate that there are no special purpose skills involved in creativity. If he is correct, then it could also be inferred that there are no special forms of mental imagery. However, Weisberg (1993) regards the imaginal processes claimed by historically creative individuals as ordinary and does not attempt to challenge the claims of Einstein and Faraday who, above all others, claimed to think creatively in mental images (Daniels-McGhee and Davies, 1994; Miller, 1989; Tweney, 1989). Furthermore, this belief is supported by research which shows that people tend to report above the expected average mental imagery (Kihlstrom *et al.*, 1991; McKelvie, 1995).

The second reason why these studies may not concur with the anecdotal evidence relates to psychometric concerns over the creativity measures used. The development of measures of creativity following Guilford's Presidential address to the American Psychological Association in 1950 suggests a meteoric rise in both the number and use of divergent thinking tasks. This reached a plateau in the late 1960s and was followed by a general disenchantment in the 1980s (Micheal and Wright, 1989). In the late 1980s and the 1990s creativity became popular again but psychometric testing played a secondary role to theoretical, developmental, and computational accounts (Boden, 1990, 1994; Johnson-Laird, 1993; Karmiloff-Smith, 1993; Ochse, 1990; Post, 1994; Zohar, 1990).

The disregard for cognitive measures of creativity may reflect a feeling that biographical and personality studies (Amabile, 1982; Eysenck, 1994, 1995; Gardner, 1993, 1994; Gruber and Davis, 1988; Perkins, 1994) are now seen as a better means of understanding individual differences in creativity. However, the movement away from psychometric testing is also linked to a number of problems associated with creativity tests (Feldhusen and Goh, 1995; Hocevar, 1979; Hocevar and Bachelor, 1989). In a review of these issues Micheal and Wright (1989) list a wide range of concerns about the test administration, reliability, content, criterion and construct validity, and scoring of these tasks. They conclude that collaboration is required between theoreticians and psychometricians to develop measures that properly reflect creative abilities.

While Micheal and Wright (1989) are correct in their assertion that there are many problems with the tests available to individual differences researchers they do so by undermining many positive accounts of these tasks that show that these albeit imperfect measures do have limited predictive validity. The most frequently used measures of

creativity in the studies reviewed here were those selected from Torrance's battery of divergent thinking tasks (e.g. Torrance, 1974). These tests have been available for many years and Torrance and others (Eysenck, 1994, 1995; Torrance, 1988) have shown an association between performance on these tests and future creative achievement. Similarly, Barron's Symbolic Equivalence Task (Barron, 1988) was shown to be a good indicator of present creative achievement. Thus, while there remain problems with creativity tasks there is at least some evidence that supports their continued use in individual differences research.

There is, of course, also evidence of psychometric problems arising from the use of self-report measures of mental imagery (Ashton and White, 1980; McKelvie, 1995; Hiscock, 1978). Several studies have questioned whether these questionnaires actually measure mental imagery abilities (e.g. Ernest, 1977; Hiscock, 1978; and, Slee, 1988). Furthermore problems (i.e. response leniency, unaccountable sex differences and social desirability) pervade despite attempts to minimise their effects; the results from the present research testify to this. The functional utility of these measures is often small and where medium effect sizes have been shown they do not appear to be very robust (McKelvie, 1995). Nevertheless the present review does show that there is some shared variance between vividness measures and divergent thinking tasks.

One question that needs to be answered is, given the above problems why do researchers continue to rely upon self-report measures of mental imagery? One answer is that mental imagery is simply problematic regardless of the measure used to investigate it. The operational indicators of its use in mentation seem to have as many problems as the questionnaires (Broerse and Crassini, 1984; Chambers and Reisberg, 1985; Intons-Peterson, 1983; and Pylyshyn, 1973, 1981). Furthermore, for some aspects of mental imagery associated with creativity (e.g. vividness) there does not appear to be an objective measure available. Nevertheless, the paucity of studies utilising chronometric and accuracy measures of individual differences (e.g. mental rotation and comparison tasks) does leave a gap in the research. This issue is partly redressed in the following chapters where creative image generation tasks are assessed in respect of both objective and subjective measures of mental imagery.

Finally, even if the validity of the measures typically employed in the individual differences approach is accepted, it does not necessarily mean that mental imagery

provides a useful method for performing the divergent thinking tasks. In Chapter One it was demonstrated that mental imagery may be useful in the creative process but it is neither a necessary nor a sufficient condition for producing creative responses. As the empirical evidence provided in the last three chapters shows only a small relationship between self-reported mental imagery and divergent thinking it is necessary to employ measures of creativity that are theoretically linked to mental imagery. This issue is addressed in the following chapters where the role of mental imagery in an imagery-bound creativity task is assessed through the application of the individual differences approach.

The third explanation for the failure of these studies to demonstrate an important role for mental imagery in creativity is the opposite to the first account. This explanation states that historically creative individuals are special and therefore have special ways of thinking that could not be unearthed in studies using samples drawn from the 'ordinary' population. That Dali, Einstein, Faraday, Kekulé, Tesla and all the others who report the use of mental imagery are special is beyond doubt but do they have special forms of mental imagery? There is some support for a clearly distinguishable difference between these individuals and the general population. The reports of Mozart and Coleridge, for example, suggest that they had extremely vivid imagery; though the reports must be seen in the context of Weisberg's research (1993). The reports of Faraday and Einstein lay claim to a non-verbal thinking that seems inconceivable. Furthermore, the review of synaesthetic imagery carried out in Chapter Three showed that many historically creative individuals have special imagery skills. Finally, even where the processes are similar the motivation of these individuals to use mental imagery is surprising. Consider, for example, Edison and Dali's methods for exploiting their hypnagogic imagery (Mavromatis, 1987).

There are of course many examples of the use of mental images by historically creative individuals (e.g. daydreaming, dreaming, and reverie) that are typical of the general population or specific to circumstances that are available to a wide number of individuals in the population (e.g. opium-induced hallucinations). Coupled with this there now exists a well established experimental protocol that has demonstrated that 'ordinary' individuals are capable of using imagery to produce creative responses (Finke and Slayton, 1988). This method, defined earlier in the thesis as the image generation

approach, involves the generation, transformation and synthesis of stimulus parts into novel composite forms. Though the protocols used are not amenable to an individual differences approach it should be possible to construct a derivative form that enables comparison with performance on both imagery and creativity tasks. This is the aim of the next chapter.

The final possible reason why these results did not live up to the expectations produced from the anecdotal reports is related to the methodological approach adopted by these researchers. If it is assumed that the measures used in these studies minimally perform their task and that many historically creative achievements use mental images available to the ordinary person, then it is necessary to return to these reports to understand why the association was so small. If this is done then it is immediately obvious that these studies have not given mental imagery (or creativity) a real chance. Quite simply the administration and presentation of the creativity measures is not amenable to the use of mental imagery in the manner reported by historically creative individuals. As was noted in Chapter Three the majority of the reports of the use of mental imagery in creativity occur in situations where there is minimal perceptual conflict or maximum perceptual facilitation. This area is dealt with in more detail in Chapter Ten.

Conclusion

It is concluded that the individual differences approach has established that self-reported mental imagery abilities are consistently but minimally associated with performance on divergent thinking tasks. Though there have been many attempts to show why an association exists between the two variables these appear to be carried out in ignorance of the strength of the association. That is, that mental imagery reports only account for 2% of the variance in the divergent thinking measures used. It would therefore appear more useful to explore the reasons why the relationship is so small prior to assuming that it is larger in some individuals because they have x,y. or z cognitive attributes.

In considering why the relationship is small four explanations emerge. The first of these claims that the mental images reported by historically creative individuals were part of a set of confabulations used to promote a 'specialness' concept of creativity. The second account explains the failure in terms of the inadequacy of the measures used to

investigate the association. The third is a special form of the individual differences approach in that it defines historical creativity, and its concomitant images, as different from ordinary creativity. The final explanation states that the methodology employed in the individual differences approach does not allow for the use of mental imagery in creativity. This account calls for a greater understanding of the role of perceptual conflict and facilitation when researching the relationship between mental imagery and creativity.

While it is probably the case that all of these explanations account for the findings, in at least some small form, some have greater consequences for future research than others. The first and third arguments are negative in the sense that they do not allow the average researcher to assess the association any further. The second and fourth explanations are positive in that they do allow for a greater understanding of the relationship between mental imagery and creativity. These are dealt with in the proceeding research where the individual differences approach is applied to an image generation approach.

Chapter VII

The Image Generation Approach

Introduction

The research presented in Chapters Four, Five, and Six showed that self-reported vividness of mental imagery is consistently associated with performance on divergent thinking tasks. However, the association between the two variables is weak and there is no evidence that any one intervening variable could strengthen the association. Given the failure to find a statistically consequential association, using the psychometric approach, the aim of the following chapters is to investigate Finke's image generation approach (creative visualisation) from an individual differences perspective. As there has been no previous research into the role of individual differences using Finke's creative visualisation task, much of the work that follows is exploratory. The aim of the present chapter is to discuss the nature of the image generation approach and to evaluate a test-format version. In the following chapters the role of mental imagery in the task is evaluated using behavioural and self-report measures.

Throughout the thesis it has been noted that there is considerable anecdotal support for the use of mental imagery in creativity. Although useful, these anecdotes are open to the 'myth of genius' account described in the previous chapter (Weisberg, 1993). Thus, the truth of the claim that mental imagery plays a role in creativity can only be properly addressed through empirical research. Until the late 1980s there had been little or no attempt to experimentally investigate creativity and imagery. However, since Finke's development of a creative visualisation task, the use of mental imagery in creative visualisation has allegedly been established (Finke, 1990; Finke and Slayton, 1988; and, Finke, Ward, and Smith, 1992). Nevertheless, there is still a need for more research into how mental images operate in these tasks. The aim of the present chapter is to develop a test-format version which can be used to distinguish abilities on the tasks. Once this is achieved it will be possible to assess the role of mental imagery in the task.

As Finke and others have demonstrated that creative forms can emerge from tasks involving the mental synthesis of stimulus parts (Anderson and Helstrup, 1993; Finke, 1989, 1990, 1996; Finke and Slayton, 1988; Finke, Ward and Smith, 1992) it should be possible to demonstrate that some individuals are capable of producing more composite forms than others. In doing so, several questions arise. The principle question that arises is, do individuals who perform well on the creative visualisation task also perform better on imagery tasks that may utilise the same processes? A further question one may ask is,

how do mental imagery and creativity interact to produce responses on the creative visualisation task? To answer these questions a performance measure of the creative visualisation task needs to be developed. This is the aim of the present chapter. First, however, it is necessary to outline the development and nature of the creative visualisation protocol.

Emergence in Mental Imagery Experiments

Finke and Slayton's (1988) work on creative visualisation may represent the first attempt to demonstrate the emergence of unexpected and divergent composite forms in an imagery task but there are many examples of expected and convergent emergent forms. These have been developed to demonstrate a perceptual equivalence for mental images. As Finke (Finke and Pinker, 1982; Finke, Pinker, and Farah, 1989; and, Finke and Schmidt, 1977, 1978) has played a significant role in the development of these experimental protocols an initial overview of "emergence" in mental imagery studies will be undertaken. "Emergence" in mental imagery research refers to unexpected forms coming into being as a consequence of imaging.

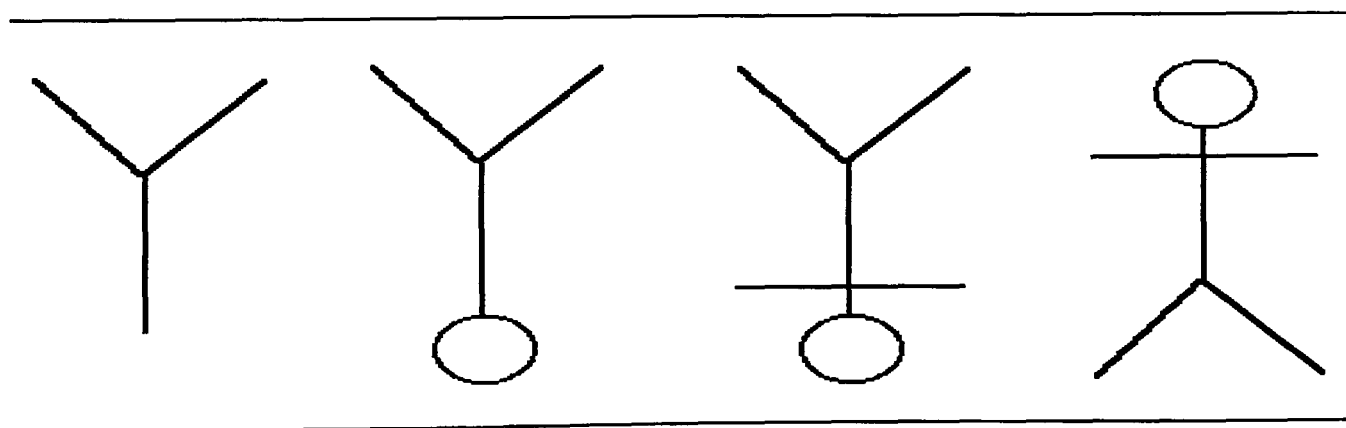
Mental imagery research in the past three decades has bristled with studies using an emergence paradigm. In fact all of the major experimental protocols claim to have a degree of emergence. This is hardly surprising as one consequence of not having emergence is that the participants comply to experimental demand characteristics. Viewed this way emergence is a crucial area of debate (Kosslyn, 1980,1981; and Pylyshyn, 1981) and a key driving force for continued experimental research (Broerse and Crassini, 1984; Chambers and Reisberg, 1985, 1992; Denis and Carfantan, 1985, 1986; Finke and Pinker, 1982; Intons-Peterson, 1983; Jolicoeur and Kosslyn, 1985; Mitchell, and Richman, 1980). This research is based upon the notion that once an experimental protocol has been established the existence of emergence demonstrates participant naiveté.

While an additional demonstration of emergence is an essential component of mental imagery research many experiments use emergence as a fundamental feature of the protocol. The most obvious group of studies which seek emergence are those which employ imagery versions of well established visual illusions and after-effects. These studies have investigated a wide range of effects, including colour after-effects, the phi-phenomenon and size constancy effects (Broscole, Chan, Brandt-Tiven, Miller, and

Sanders, 1997; Broerse and Crassini, 1980; Finke and Schmidt, 1977, 1978; and, Wallace, 1984). Though there have been successful demonstrations of the emergence of perceptually equivalent effects (Brosigle *et al.*, 1997; Cerfe-Beare, 1993; Finke and Schmidt, 1977, 1978; Wallace, 1984) there are also alternative findings that challenge emergence (e.g. Broerse and Crassini, 1984; Reisberg and Morris, 1985; Rhodes and O'Leary, 1985). There has also been research that demonstrates a failure to find perceptually equivalent emergence in complex tasks (Chambers and Reisberg, 1985). Thus, studies of imagery-based perceptual anomalies have not fully demonstrated the existence of emergence in mental imagery.

Emergence is also a key descriptor of the experimental protocol in tasks where individuals are required to perform operations upon an imaged form. This may take the form of rotation or manipulation in spatial imagery tasks (Cooper, 1990; Cooper and Shepard, 1973; and, Shepard and Metzler, 1971) or it may be more directly imposed upon the imaginal system in tasks involving the synthesis of fragmented forms (e.g. Finke, Pinker and Farah, 1989). The latter tasks require participants to amalgamate, transform or mutate a number stimulus parts into a form that is only recognisable as a composite whole. For example, Kosslyn, Reiser, Farah, and Fliegel (1983) carried out a study in which participants were required to synthesise fragmented parts of line drawings (e.g. a cat). They found that emergent solutions occurred in explicit imagery tasks but not in control conditions where imagery instructions were not presented.

Figure 7.1. An Example of the Mutation and Transformation Stimuli Employed in Finke, Pinker, and Farah's (1989) Study of Emergent Patterns in Imagery



The clearest demonstration of emergence in mental imagery tasks was provided in a series of studies conducted by Finke *et al.* (1989). These studies required the

participants to use their imagery to combine, superimpose and manipulate verbally described stimulus forms. For example, in a typical trial they may be asked to: imagine the letter 'Y', to add a circle to the bottom of the letter, to add a horizontal line just above the circle, and to rotate the composite form 180°. If the participant is able to perform the task the emergent form should be a stick man (see Figure 7.1). Results from these studies showed that people were capable of recognising simple emergent structures following several transformation procedures. These tasks appear to be especially pertinent to the perceptual equivalence hypothesis because they are not susceptible to tacit inference, task demands and non-imagery heuristics.

Creative Cognition

Having shown that when people are asked to manipulate mental images they often find experimentally predictable emergent forms, Finke developed a procedure to assess the significance of experimentally unpredictable emergent forms. Finke and Slayton (1988) hypothesised that people taking part in a mental synthesis task could generate, transform and synthesise simple stimulus parts (e.g. a circle, the letter 'J' and the number '8') into experimentally unpredictable but recognisable composite wholes. In a study of over 850 of these tasks they showed that recognisable composite forms were produced in 40% of the trials and that 15% of these were independently defined as creative. Further research also found that only a small proportion of the creative responses were predictable in the sense that they could be guessed without mentally synthesising them. Furthermore, research into mental and physical synthesis has demonstrated that creativity is not improved with external support (Anderson and Helstrup, 1993). Thus, mental imagery seems to be important in this particular form of creativity.

Finke and Slayton's (1988) research into creative mental synthesis has provided a useful protocol for further investigation into mental imagery and creativity. However, the exact procedure left several very basic questions unanswered. These include the usefulness of mental synthesis in real-world problem solving (where implementation often involves functional and categorical constraint) and the importance of generation and interpretation in the creative visualisation task.

The functional utility of mental synthesis protocols was evaluated by transferring the task requirements to the creative invention of composite forms in three-dimensional

stimulus parts (Finke, 1990). The inventions produced by participants matched those found in the Finke and Slayton task (1988) in both frequency and the number of creative responses. Finke (1990) also investigated the effects of constraint (e.g. restricting the composite forms to particular categories) on composite form generation. In several studies in which category (e.g. weapons, tools and utensils, and furniture), object (type of weapon, tool, or furniture), function (e.g. “a piece of furniture that a handicapped person could use”), and stimulus part (e.g. sphere, cylinder, and handle) were determined and freely selected Finke found that constraint generally had a positive effect on creative performance. In only one of these cases was constraint shown to be disadvantageous because it limited the number of possible responses available to the individual. The effect of constraint tends to show that so long as the range of responses is not too specialised it forces the person to think more creatively about the task (Finke *et al.*, 1992).

Finke (1990) was also interested in distinguishing the roles of generation and interpretation in the creative visualisation task. The need for such an investigation was apparent in the ambiguous interpretations of some of the composite forms found in the Finke and Slayton task. These begged the question as to whether interpretation occurs pre- or post- the synthesis of the stimulus parts. To address this question Finke (1990) altered the protocol so that the participants interpreted ‘pre-inventive’ composite forms in the context of randomly selected categories. The results showed that regardless of whether the participants had created the pre-inventive forms there was a reduction in the number of solutions achieved. However, when the participants were given pre-inventive forms the proportion of creative inventions produced was equivalent to the previous tasks performed by Finke and Slayton (1988). Furthermore, where they formed their own pre-inventive forms the proportion of creative inventions was greater (approaching 50% of the total number of practical responses).

Since its inception the creative visualisation task has consistently showed that synthesising and interpreting mental images can result in the emergence of creative responses. It therefore seems to be an ideal protocol for furthering the understanding of the role of mental imagery in creativity. The aim of the following study is to develop a test-format version of Finke and Slayton’s original creative visualisation task. Provided that it can be demonstrated that this task has acceptable parametric properties, the role of

mental imagery in creativity can be explored in ways that have not previously been investigated.

Study Eight. Piloting a Test-Format Version of Finke and Slayton's Creative Visualisation Task

Introduction

As a preliminary inquiry into the role of mental imagery in Finke's creative visualisation task (Finke, 1989, 1990, 1992; 1996 Finke and Slayton, 1988), the aim of the present study was to develop a test-format version of the task using the stimulus parts from Finke and Slayton's creative visualisation task. The only constraint was that the format simulates the standard performance tests used in psychological research whilst retaining the use of image transformation and synthesis. This is necessary as the creative visual synthesis task used in previous research does not yield acceptable parametric properties

Several forms of the creative visual synthesis task have been developed in the past decade (Anderson and Helstrup, 1993; Finke, 1990; Finke and Slayton, 1988). However, all of these have followed the protocol used in the original Finke and Slayton version. This protocol requires participants to generate a composite form from three randomly selected stimulus parts. If the participant has been successful they are required to make a brief sketch of the generated form. These sketches are then rated by judges for correspondence on a one to five scale ranging from poor to good. If they are defined as good correspondences they are assessed for creativity using independent judges ratings.

The creative visualisation tasks used by previous researchers provide information about whether people can perform the task and the proportion of responses that are correspondent and creative. They have not been used to show that people differ in their abilities to produce correspondent and creative responses. This emphasis upon demonstration means that these tasks are assessed for frequency of occurrence rather quantity of performance. As the thesis focuses on how and why people differ in their creative abilities there is a need to transform the creative visualisation task into a form that produces acceptable parametric properties. The method used in the present chapter is derived from the standard divergent thinking measures (Barron, 1988; Guilford, 1969;

Torrance, 1972). That is, the tasks are presented in a pencil and paper format and the participants are given a specified amount of time to produce creative responses from a range of stimuli.

To develop a standard pencil and paper test-format version of the creative visualisation task several adjustments to the standard protocol needed to be made. Firstly, it was necessary to provide the participants with sets of standard stimulus part assemblies. The advantage with this is that all of the participants receive the same sets of stimuli. This enabled the raters to further differentiate convergent and divergent stimulus part assemblies. Thus, randomness was sacrificed in favour of conformity. Secondly, it was also necessary to present the stimulus parts in a pictorial form. One disadvantage with this approach was that it placed less demand on the image generation procedure. However, as later studies (Finke, 1990) found that there were a larger proportion of creative responses when the participants were presented with composite forms then freeing the generation procedure may result in less demand upon the imaginal system. The aim of this study was to pilot a test-format version of the creative visualisation task.

Method

Participants. Twenty-five participants with a median age of 20 (ranging from 18 to 37) volunteered to take part in the study. All were undergraduate psychology students at Middlesex University. One participant failed to comprehend the nature of the task and was therefore removed from further analyses.

Design. The aim of the present study was to evaluate the parametric properties of the task. As an adjunct self-report measures were also taken to assess the participants' beliefs about how they performed the task.

Materials. A test-format version of Finke and Slayton's (1988) creative visualisation task was developed in the form of a standard paper and pencil task (see Appendix 7.1). The instructions on the task informed the participants that they would be presented with a series of stimulus parts and that they would be required to mentally integrate these forms into a composite object or scene. A total of seven stimulus part sets was presented and the participants were required to think of up to three composite forms for each set. These were presented in the same order and consisted of four sets of three stimulus parts (square, circle, line; triangle, letter 'L', circle; square, oblong, circle; and,

triangle, cross, line). Two sets of four stimulus parts were also presented (triangle, semi-circle, square, letter 'T'; and, ellipse, oblong, circle, line) and a final set consisting of six stimulus parts was given (triangle, circle, letter 'T', line, line, square). The participants were informed that they were free to choose the order of completion and were encouraged to move on to further sets if they were unsuccessful in forming composite forms.

Instructions. On every page of the task the procedure and the rules underlying integration were specified. The instructions for each stimulus part integration were as follows:

1. Think of an object or a scene.
2. Write down the title.
3. Draw a brief sketch of the object or scene.

Underneath the instructions the rules for integration were specified. These were stated as:

1. You can rotate the stimulus parts.
2. You can change the size of the stimulus parts
3. You cannot change the basic shape of the stimulus parts.

The participants were informed that they must adhere to these rules and that drawing support (e.g. drawing single stimulus parts) was not allowed. Intermittent observation was carried out and *post facto* checks on drawing support confirmed that the participants complied with the rules and procedures.

Self-report Measures. Five visual analogue scale measures (ranging for 0-100mm) were presented to the participants after they had performed the creative visualisation task. These were intended to gauge beliefs about the difficulty of the task and the type of strategies they used. The first of these asked the participants how difficult they felt the task was. It was anchored from '*very difficult*' to '*very easy*'. The second scale measured the participants awareness to solution. This was anchored from '*always aware*' to '*never aware*'. The three strategy scales (mathematical, verbal, and imagery) measured the participants' beliefs about how they created the composite forms. These were anchored from, '*always used*' to '*never used*'.

Procedure. The participants performed the creative visualisation task on their own in sound attenuated cubicles. After reading the instructions they were further informed of the nature of the task and having established that they understood the task they proceeded

to work as quietly and quickly as possible. Once the study had been completed the composite forms were scored by two raters on the basis of the three attributes listed below.

Scoring Instructions. The judges were informed about the nature of the task and were asked to make three judgements about each composite form. The first task they performed was to identify the number of correct responses. To be judged as a correct response the composite form had to conform to the following criteria:

1. It integrated all of the given shapes.
2. It did not include any other shapes.
3. The person provided a title
4. The object or scene fulfilled a minimal correspondence with the title

If the response was judged to be correct it was rated on a five-point scale (ranging from 'Very Poor' to 'Very Good') of the correspondence of the form to the description. Finally the rater was required to state whether or not they thought the composite form was creative.

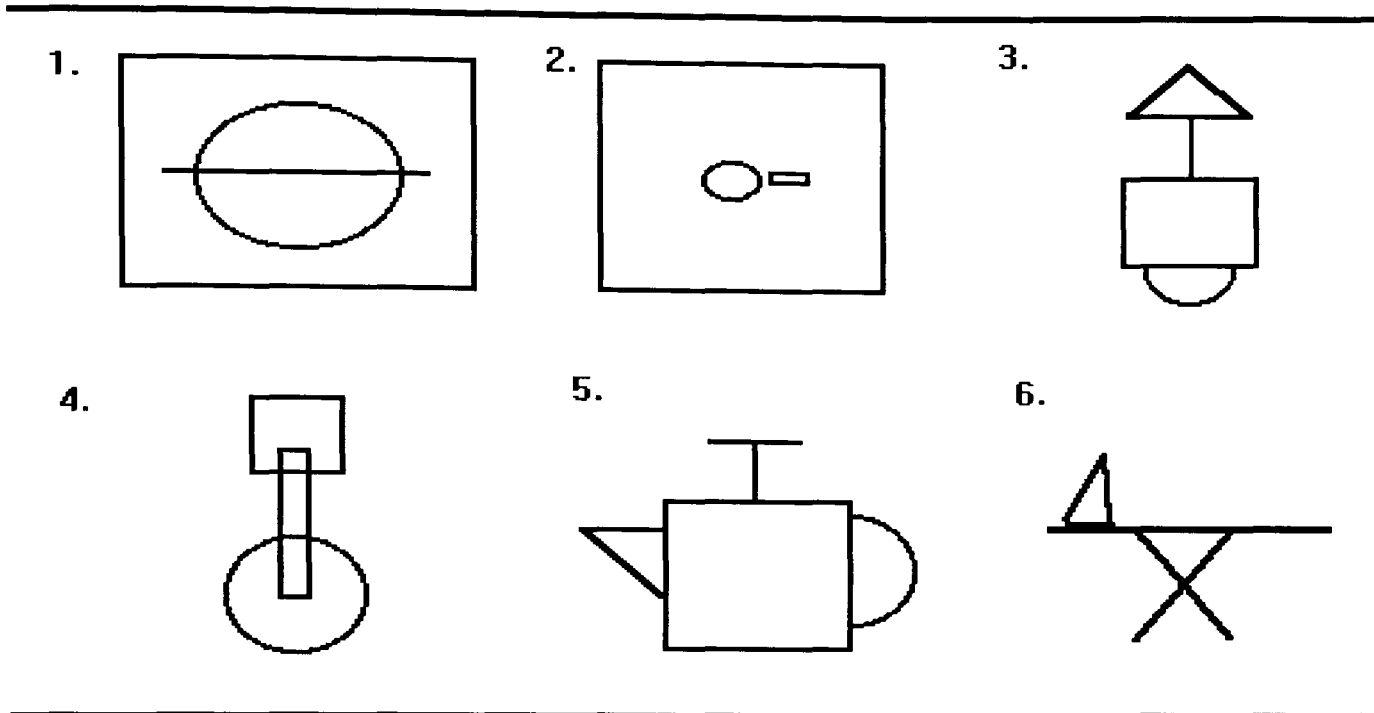
Results

The aim of the present study was to evaluate the parametric properties of the test-format creative visualisation task and the type of cognitive strategies the participants report using to create composite forms. Following the completion of the task the scores from the creative visualisation task were rated by two judges for: the number of acceptable responses, the degree of correspondence between the composite forms and what they were said to be representing, and the creativity of the composite forms. As the ratings exceeded the 0.7 criterion adopted for inter-rater response measures the scores were collapsed for acceptability and correspondence. A score for creativity was only given if both judges agreed that the composite form was creative.

While there were a large number of non-creative responses some very interesting and unexpected composite forms were produced. The ability to transform, rotate, and combine the stimulus parts (all presented in a standard size format) is clear from the examples given above. In viewing these responses it seems apparent that they could only be produced by using mental imagery. Consider any of the examples presented in Figure

7.2 and it is clear that the stimulus parts would have to be rotated or transposed in quite complex ways to produce the final product.

Figure 7.2. Examples of Responses Scoring High on Correspondence and Rated As Creative By Two Judges.



1. Underground sign (square, line, circle); 2. Floppy disk (square, circle, rectangle); 3. Ice cream stall (triangle, line, square, semi-circle); 4. Unicycle (square, rectangle, circle), 5. Coffee pot (letter 'T', square, triangle, semi-circle), 6. Ironing board (letter 'X', line, triangle).

Basic data screening for skewness and kurtosis of the three measurements derived from the test-format revealed good parametric properties. Table 7.1 shows that all of the participants managed to produce at least one response (though one judge gave a zero rating for a participant on the number of acceptable responses) and that the average number of freely produced responses exceeded Finke and Slayton's one-per-two minute protocol (i.e. the maximum number of responses produced using this protocol is five). The ability to represent the responses averaged 2.1 per response which is below an average correspondence rating. Finally, the number of creative responses (29% of the total responses) shows that the participants followed the instruction to integrate the stimulus parts in as creative a way as possible.

Table 7.1. A Descriptive Analysis of the Measures Derived from the Test-Format Creative Visualization Task (n=24)

Measurement Scale	Mean	St. Dev.	Min.	Max.
Number of acceptable responses	6.71	3.00	1	14
Total Correspondence ratings	13.89	6.69	1	28.5
Total Creative responses	2.00	1.59	0	6

Descriptive statistics of the self-report measures are presented in Table 7.3. An analysis of difficulty showed that the participants rated the creative visualisation task as above average in difficulty ($t(21)=3.64$, $se=4.89$, $p<0.001$). A one-sample t-test on the participants' perceived awareness of the solution showed that, although they tended to report awareness, this was not statistically significant ($t(21)=1.64$, $se=5.08$, $p>0.05$). Self-report measures of strategies employed to perform the task showed that the participants reported using a verbal comparison below the mid-point on a '*never*' to '*always*' scale ($t(22)=-1.90$, $se=5.90$, $p<0.05$). The participants also reported rarely using a mathematical comparison strategy ($t(-5.61)$, $se=4.39$, $p<0.001$). Finally, even though the participants were never explicitly asked to use mental imagery they rated its use significantly above the mid-point ($t(21)=3.38$, $se=5.46$, $p<0.01$). These measures therefore support the assumption that mental imagery is used in the creative visualisation task.

Table 7.2. Self-report Ratings of Difficulty and Strategy Used to Perform the Test-Format Creative Visualisation Task (n=24).

Self-report measure	Mean	St.Dev.
Task Difficulty	69.95	22.93
Awareness of Solutions	58.32	23.83
Use of a verbal comparison strategy	39.45	26.07
Use of a mathematical strategy	25.36	20.60
Use of a general mental picture strategy	68.45	25.62

Discussion

This brief study of the test-format version of the creative visualisation task demonstrates that it is possible to construct a measure which conforms to the parametric

properties found with other test-format tasks. Though the participants generally reported difficulty in completing the task, the fact that the judges found nearly seven responses per participant acceptable shows that the task is possible. Finally, though no references to mental imagery were made by the experimenter (or were presented in the task) the self-report measures suggest that the participants frequently employed mental imagery in the task.

In evaluating these findings in the context of Finke and Slayton's (1988) research it is necessary to understand the different scoring procedures used. The correspondence scale was altered and the criterion for acceptance was changed so that the judges used a two-tier system of correspondence. In the first instance they were instructed to make an assessment of sufficient correspondence. If the composite form passed this test it was then evaluated according to the degree of correspondence on a five-point scale. The result of this process was that the correspondence scores were generally lower than those found by Finke and Slayton (1988). However, this is partially offset by an increase in the number of responses produced and a greater proportion of creative responses.

In summarising this study it is concluded that a measure can be produced which shows good parametric properties. One of the consequences of developing the test in this format is that the overall correspondence between the composite form and what it is said to represent is reduced. However, this seems to be a natural consequence of this performance version. Furthermore, this is counteracted by an increase in both the quantity of responses produced and the proportion of creative responses.

As the study has shown that a test-format version of the creative visualisation task can be developed which has acceptable parametric properties and elicits responses that can be judged on measures of acceptability, correspondence, and creativity it is possible to explore the roles of imagery and creativity in the task. As this research has not been conducted before it is necessary to assess which measures of mental imagery may predict performance on the creative visualisation task. Such an undertaking is even more speculative because the previous research into individual differences in mental imagery and creativity has focused solely upon self-reported mental imagery.

Chapter VIII

The Role of Behavioural Measures of Mental Imagery in Predicting Performance on the Creative Visualization Task

General Introduction

In previous chapters it was noted that individual differences research into mental imagery and creativity has predicted divergent thinking performance on the basis of self-reported mental imagery. Behavioural measures of mental imagery that assess rotation, scanning and comparison effects have not been used to study how mental imagery differences may influence performance on divergent thinking tasks. The use of self-report measures in previous studies of mental imagery and creativity seems to have been based upon convention rather than any stated theoretical rationale. As an alternative approach the aim of the present chapter is to assess the role of behavioural measures in performance on the test-format version of the creative visualization task. This will be achieved through two studies of mental imagery and creative visualization. In the first study a simple high and low mental rotation latency and accuracy split is employed to investigate whether imagery differences predict performance on the creative visualization task. The second study in this chapter investigates imagery-based and non-imagery based mental comparison performance. Initially, a review of the forms of behavioural predictors of mental imagery ability is undertaken.

Behavioural Measures of Mental Imagery

The pilot study carried out in Chapter Seven showed that it is possible to construct a test-format version of the creative visualization task that has adequate parametric properties. As this version of the creative visualization task produces a sufficient range of scores it is possible to evaluate the association between mental imagery and creativity in the task. The aim of the present chapter is to select and implement behavioural measures of mental imagery as alternative predictors of performance on the creative visualization task.

In Chapter Three a range of mental imagery tasks was discussed in the context of their validity and their relationship to mental imagery. Although these measures are normally used to demonstrate a representational or stimulus attribute hypothesis (J.T.E. Richardson, 1999) they have also been employed as individual differences measures (Farah, Hammond, Levine, and Calvino, 1989; Paivio, 1978a; Wethearly, Ball, and Stacks, 1997). This is because many of these tasks provide good indicators of

performance and therefore show an individual's ability in that particular form of mental imagery. In Table 8.1 some of the most common tasks used in mental imagery research are listed. As an aid to evaluating the usefulness of these measures in individual differences research the processing and response attributes have been stated.

Table Four. Examples of Mental Imagery Tasks and the Hypothesised forms of Instruction, Imagery and Quantification

Task	Instruction	Imaginal Processing	Form of Prediction
Imagery After-effects	E	G	PC
Imagined Ambiguous Figures	E	G, RFA	PC
Creative Visualisation	E	G, T, C, I	BC, BP
Convergent Emergence	E	G, T, C, I	BC, BP
Imagery induced Illusions	E	G, I	PC, BP
Imagery Mnemonics	E	G, Rec	BP
Mental Clock digit Comparison	E	G, T, S, Com	BCh
Mental Picture Comparison	I	T, S, Com	BCh
Mental Rotation	E-I	T, Com	BCh
Mental Scanning	E-I	G, Sc, Co	BCh, PCh
Paired Associate Learning	E-I	G, Comb	BP
Picture Memory	I	G	BP

Key Instruction (E - Explicit, I- Implicit)

Key Imaginal Processing (G-Generation, RFA- Reference frame adjustment, T-Transformation, C-Composition, Com-comparison, I-interpretation, Rec-Recall, S-Superimposition, Sc-Scan, Co-Confirmation, Com-Combination.)

Key form of prediction (BC = Behavioural confirmation, BCh = Behavioural chronometric, BP =Behavioural Production, PC = Phenomenal Confirmation, PCh = Phenomenal Chronemtric

An examination of the processing responses employed in these measures suggests that any of the protocols could provide useful predictors of performance on the creative visualization task. Consequently any decision about which measure best predicts performance on the creative visualization task is controversial. However, it is necessary to decide upon which measure is the most appropriate predictor of performance on the creative visualization task.

Studies investigating anomalous perceptual experiences occurring in mental imagery (e.g. imagery after-effects, imagined ambiguous figures, and imagery induced illusions) provide valuable information about the generation of mental images (Broscole *et al.*, 1997; Finke and Schmidt, 1977, 1978; Wallace, 1984). However, as the existence of these effects is controversial (Broerse and Crassini, 1984; Chambers and Reisberg, 1985.

1992), it would not be sensible to use these measures as an indicator of individual differences.

Studies of the role of mental imagery in memory have been reviewed in Chapter Three. These cover a wide range of measures and provide valuable information about how stimulus attributes, individual differences, and imagery strategies effect memory performance (Atkinson and Raugh, 1975; Logie, 1986; Marks, 1973; Paivio, 1971; Quinn and McConnell, 1996). However, research into the function of memory in creativity is centrally concerned with heuristic transfer (Stein, 1989). As this aspect of creativity is not being investigated in the present research it is unlikely that the mediating effects of mental imagery ability will be of major importance.

Four broad categories of task remain (convergent emergence tasks, mental comparison tasks, mental rotation tasks, and mental scanning tasks) and any decision made is necessarily arbitrary. The two measures that have been selected for empirical review are mental rotation and mental comparison. The decision to investigate these measures over the others is based upon several factors. As was noted in Chapter Three, the mental rotation protocol is the best known and most widely used behavioural measure of mental imagery. It has been thoroughly reviewed by researchers and seems to measure spatial imagery abilities (Kosslyn, 1994). As an introductory investigation into behavioural predictors of creative performance it would therefore seem to be the most suitable measure of spatial imagery. The mental comparison task has different advantages over the other measures. The most apparent of these is that equivalent tasks can be produced which do not involve imaginal processing. This is useful because it provides information about the role of imaginal and non-imaginal processes. Furthermore, it is the only protocol in the current range that has been shown to measure a hypothesized dissociable visual imagery (Farah *et al.*, 1989).

In the following studies two behavioural measures of mental imagery will be used to investigate the role of mental imagery in the test-format version of the creative visualization task. There are several reasons why they have been selected. There is a paucity of research investigating the role of behavioural measures of mental imagery in creativity and so these alternative measures of individual differences in mental imagery ability warrant investigation. The mental rotation task is hypothesized to measure spatial ability and the mental comparison task is hypothesized to measure visual imagery. As it is

not clear what the role of mental imagery is in the test-format creative visualization task, the provision of two distinct measures of mental imagery may further the knowledge about the task. The following study investigates the role of mental rotation differences in predicting performance on the creative visualization task.

Study Nine. The Role of Mental Rotation Differences in Predicting Performance on the Test-Format Version of the Creative Visualization Task

Introduction

The mental rotation effect was first reported by Shepard and Metzler (1971) to demonstrate the role of mental images as 'functional substitutes' for percepts. In a series of experiments on the mental transformation of geometric shapes (Cooper and Shepard, 1973; Shepard and Metzler, 1971) it was shown that imagery for apparent motion follows the same principles as kinematic transformation in visuo-motor tasks. In the form developed by Cooper and Shepard (1973) participants are required to state whether a letter or number (e.g. '7' 'L' 'F' or 'R') is 'real' or a mirror image. The notation is presented at a given number of angles (e.g. 0°, 30°, 60°, 90°, 120°, 150°, and 180°) ranging from the standard presentation to an upside-down position. Very robust effects show a linear relationship (0° and 30° angles often do not conform to this effect) between the time taken to respond to whether the letter is 'real' or not and the distance the letter is from its normal upright position. These results, and the participants' self-reports, suggest that the process is identical to perceptual and kinematic effects (i.e. it is the same as physically rotating the object or watching an object rotate).

As a well replicated mental imagery measure there are several reasons why the mental rotation task may be a useful in the present investigation. The first of these concerns a hypothesized overlap in the operations used in the mental rotation and creative visualization tasks. The second is related to Shepard's claims about the role of mental transformation in creative thinking (Shepard, 1978a).

The first reason for believing that mental rotation skills may be important in determining creative visualization responses is linked to the imaginal processing requirements inherent in both tasks. The most immediate example of a possible shared processing requirement is the need to transform region-bounded depictive stimuli. In the

creative visualization task it is imperative that the three (or more) stimulus parts are transformed to achieve a composite form. Furthermore, region-bounding (i.e. that all of the stimuli must be fully contained within the visual buffer) seems inevitable at some stage of the process. So what of the transformation procedures involved in mental rotation? The use of non-imaginal processes in mental rotation tasks has received much attention (Kosslyn, 1994). These studies show that alternative strategies (e.g. attention shifting of reference framing) are unlikely to be used unless the individual is very familiar with the task. Thus, it can be hypothesized that the same region-bounded mental transformation procedures are used by naive participants in both mental rotation task and the creative visualization task.

The second reason why mental rotation may provide a good indicator of creative visualization task performance is derived from reports of the use of mental rotation in creativity. Shepard (1978a) refers to several reports of the use of mental transformation in historically creative achievements; most notably Crick and Watson's discovery of the structure of DNA. He also reports correspondence by chemistry researchers confirming the functional utility of mental rotation in the laboratory.

As a preliminary investigation into the imaginal processes involved in the test-format version of the creative visualization task, the present study is concerned with spatial imagery abilities. It is hypothesized that the development of composite forms in the creative visualization task requires some spatial imagery processing. In considering the form of spatial imagery used it is evident that this may at some stage involve the use of region-bounded processing (i.e. the stimulus parts are fully contained in the visual buffer). The mental rotation task is the most frequently used measure of region-bounded spatial imagery and performance on this task (e.g. latency and accuracy measures) may act as a useful measure of an individual's ability to use this form of imagery in the creative visualization task.

Method

Participants. Twenty-four undergraduates studying psychology at Middlesex University took part in the study as part of a course requirement.

Design. A simple independent groups design was employed with high and low imagery ability determined by median splits on reaction time and accuracy scores in the

mental rotation task. The dependent variables were the three measures of frequency, correspondence, and creativity derived from creative visualization task.

Materials. The mental rotation task was a variant form of the Cooper and Shepard (1973) letter rotation task. The experimental condition consisted of 84 trials. Seven angle distances (0° , 30° , 60° , 90° , 120° , 150° , and 180° degrees) were used with 12 trials presented in each condition. The letter stimuli were further broken down into three letters employing varying degrees of right reference frame information ('L', 'F', 'R'). Half the stimuli were 'real' letters and half were 'mirror' reversed. The mental rotation task used the SuperLab software package. The trials (extracted from PICT stimuli used in a demonstration programme) were randomly presented.

The same test-format version of the creative visualization task (CVT) was employed as that presented in Chapter Seven. The CVT task was rated by two judges for frequency, correspondence, and creativity of responses. Inter-rater reliability coefficients exceeded 0.8 in the frequency and correspondence measures. Consequently, the scores were collapsed and a creativity measure was collated from the judges confirmation (full procedural and scoring instructions are provided in Chapter Seven).

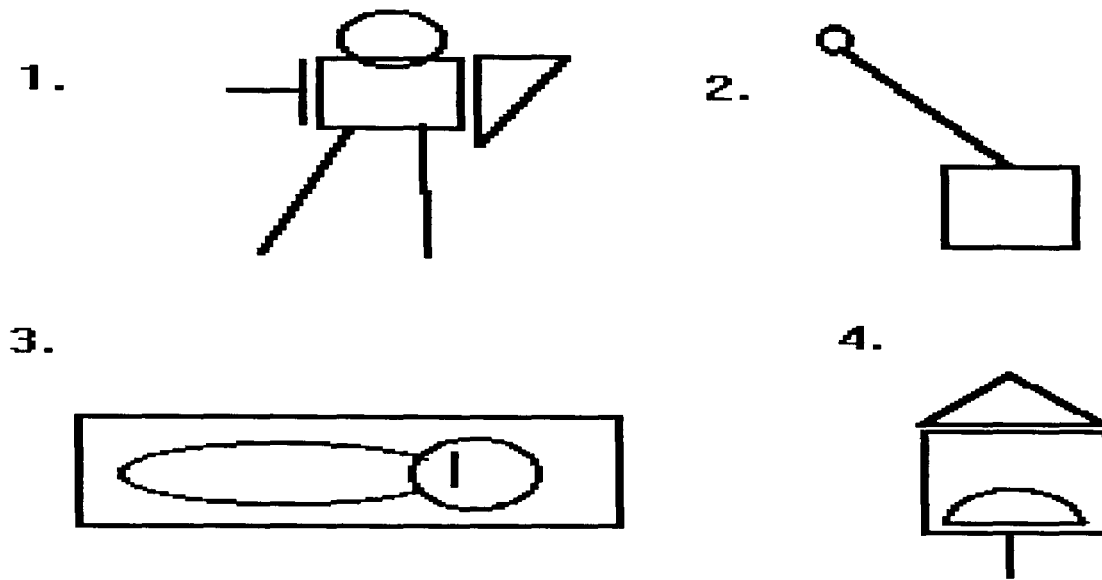
Procedure. On arrival the participants were told that they were to take part in a study of the role of mental imagery in information processing. Once they were fully aware of the nature of the mental rotation task and correctly responded to six practice trials they completed the 84 experimental trials. Following the mental rotation task the participants completed the test-format version of the creative visualization task. Together the tasks took approximately 20-30 minutes to complete.

Results

The Creative Visualization Task. The scores on the creative visualization task were similar to those reported in the previous study. Examples of the creative composite forms are presented in Figure 8.1. The frequency and correspondence of these responses suggests that participants are able to perform the test-format version of the creative visualization task. Furthermore, those forms defined as creative show that the participants were able to produce unexpected responses. One composite form in particular, defined by the participant as "an old fashioned camera", stood out from the other responses, not

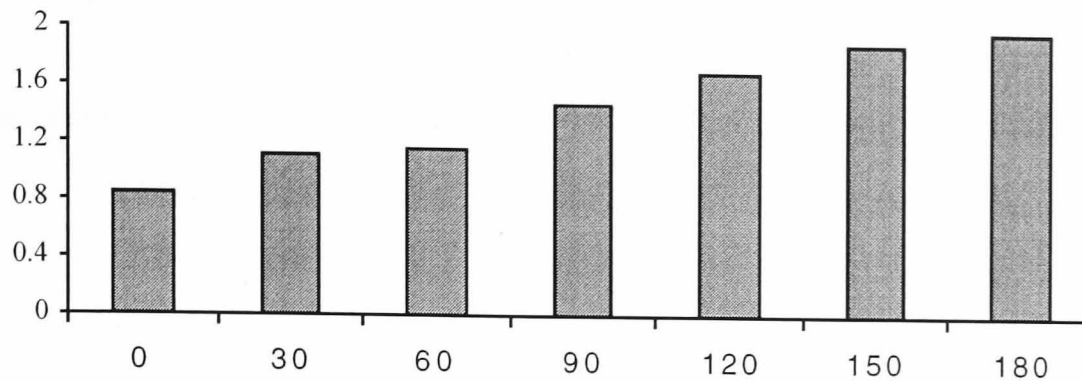
because it was necessarily more creative but because it required the composition of six stimulus part forms.

Figure 8.1. Examples of Responses to the Creative Visualization Task Which were Rated as Correspondent and Creative.



Mental Rotation Effects. A preliminary assessment of the mental rotation task was carried out to confirm rotation, fold point, congruity, and right-reference frame effects. One participant was rejected from further analyses because she failed to perform the task at the 70% correct threshold. A one-way repeated measures ANOVA on the angle distances showed a significant rotation effect ($F(6,114)=10.06$, $MSe=0.30$, $p<0.001$). Analyses of fold point using eta-squared (variance explained: $0^\circ=47\%$, $30^\circ=44\%$, and, $60^\circ=40\%$) showed that the standard upright position produced the strongest rotation effect. The participants' reaction times were significantly faster when the letter was presented in a non-reversed form ($t(18)=6.55$, $se=0.06$, $p<0.01$). A repeated measures ANOVA on reference frame information showed no significant differences between the three letter stimuli ($F(2,36)=1.28$, $MSe=0.03$, $p>0.05$). As these effects combined to support a mental rotation process (see Figure 8.2) the participants were split at the median total response time (1.15 seconds) into high and low mental rotation latency groups.

Figure 8.2. Mean Response Time (Y Axis) in Seconds for the Seven Angles of Rotation (n=24)



Mental Rotation Abilities and the Creative Visualization Task. The results from the creative visualization task are presented in Table 8.2. These show that the participants performed in a similar fashion to those in the pilot study. The average number of responses defined as appropriate by the judges exceeded six. Although those performing in the top half on the mental rotation task produced slightly more responses on the creative visualization task no significant differences were found ($t(22)=0.38$, $se=1.19$, $p>0.05$). Furthermore, no significant differences were found for the correspondence measure ($t(22)=0.14$, $se=3.47$, $p>0.05$) and the creativity measure ($t(22)=-0.50$, $se=0.84$, $p>0.05$).

Table 8.2. Mean Frequency, Correspondence, and Creativity Ratings on the Creative Visualization Task (Standard deviations are presented in brackets).

Rotation Groups	Frequency	Correspondence	Creativity
High Latency	6.45 (2.62)	15.81 (6.29)	2.90 (1.70)
Low Latency	6.00 (2.69)	15.33 (9.25)	3.33 (2.06)
Total	6.25 (2.59)	15.60 (7.53)	3.10 (1.83)

As research has suggested that accuracy may be a better predictor of mental rotation performance than latency (Wetheartly, Ball, and Stacks, 1997) further analyses were conducted using a median accuracy score (76) split. Although these findings were in the predicted direction the differences were not significant. Consequently, non-significant differences were found for the frequency ($t(22)=0.25$, $se=1.19$, $p>0.05$), correspondence

($t(22)=0.17$, $se=3.46$, $p>0.05$), and creativity ($t(22)=0.97$, $se=0.82$, $p>0.05$) measures. Overall these findings do not support a role for mental rotation ability in predicting performance on the creative visualization task.

Discussion

The preliminary results from the present study are similar to those reported in the previous studies reported above. The creative visualization measures yielded similar scores to those found in Chapter Seven. Likewise, the mental rotation task showed equivalent results to those observed in previous tasks (Cooper and Shepard, 1975). However, when the creative visualization task was assessed for high and low scorers on the mental rotation task, no differences were observed. Thus, these results suggest that the imaginal processes required in the creative visualization task are different from those required in the mental rotation task.

Preliminary analyses of the mental rotation task conformed to the standard responses produced from this experimental protocol. An angle of rotation effect was clearly demonstrated and alternative non-imagery strategies did not appear in the analyses. Nevertheless, the hypothesized role of mental rotation in performance on the creative visualization task was not found. Explanations for this failure relate to experimental factors and the nature of the mental rotation task.

Two problems with the present experiment may explain the failure to find significant differences on the three creative visualization tasks. The first concerns the failure to include left-reference frame stimuli in the mental rotation task. As all of the stimuli were right-reference frame it may be argued that the participants were able to use a non-imagery strategy unimpeded by reference frame alterations. Although this explanation is available, there are several reasons for believing that the participants employed the same strategies as those used in previous mental rotation tasks. Firstly, if they were using an attention shifting strategy then the effect of stimulus orientation should be degraded. This was clearly not the case in the present experiment. Secondly, if the data were influenced by right reference frame effects then it would be expected that the amount of reference frame information would also determine rotation performance. However, analyses of the stimuli showed that rich right reference frame stimuli ("R") were not responded to faster than impoverished right reference frame stimuli ("L").

Finally, previous research shows that attention shifting strategies are only likely to occur when the participants have either rehearsed the task or have been given explicit instructions to perform the task using a reference frame (Kosslyn, 1994)

An alternative explanation for the findings is that the creative visualization task and the mental rotation task do not use the same forms of imaginal processing. Perhaps spatial imagery (as measured by the mental rotation task) is not used in the creative visualization task. As there has been no previous research into the use of mental imagery in the creative visualization task investigation is exploratory. Participants may not need to transform mental images in a region-bounded format. It could be that the generation, vividness and comparison of mental images is important.

In conclusion, the research from the present study has failed to demonstrate an association between mental rotation and performance of the creative visualization task. Explanations for this finding may be based on the stimuli but it is more likely that the spatial imagery measured by mental rotation tasks is not relevant to performance of the creative visualization task.

Study Ten. The Role of Mental Clock and Arithmetic Comparison in Performance on the Creative Visualization Task

Introduction

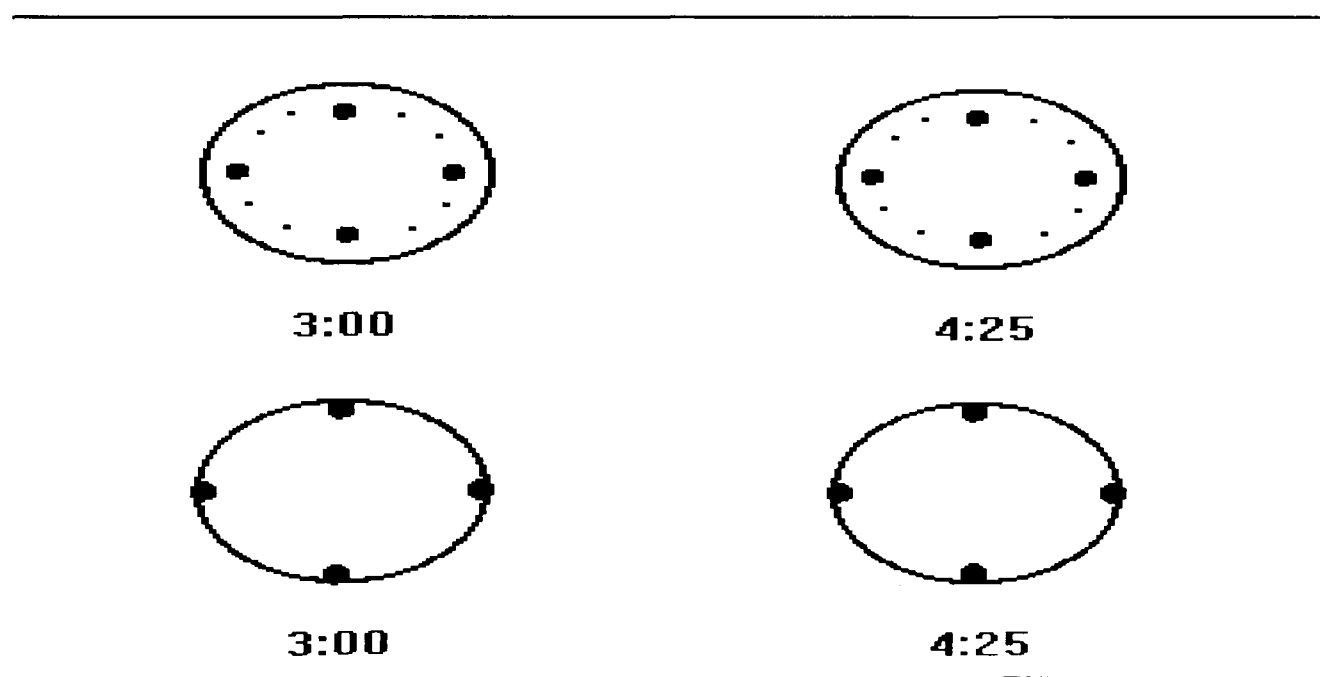
The aim of this study was to assess the generative and comparative processes involved in the creative visualization task. To do this two mental comparison tasks were developed. The first of these uses Paivio's (1978a) mental clocks protocol as a measure of imagery generation and comparison. The second uses an arithmetic equivalent form of generation and comparison hypothesized to involve no imagery processing. The role of imagery in mental comparison is discussed below.

A considerable amount of research into performance on mental comparison tasks has been carried out since the 1970s. The best known effect produced from these studies is a chronometric distance effect. This effect is described by Moyer and Bayer as, "The time needed to compare two symbols varies inversely with the distance between their referents on the judged dimension." (1976, p.230). A typical example of chronometric distance is the finding that it takes longer to recognize that an elephant is larger than a

horse than it takes to recognize that an elephant is larger than a mouse. Dimensions which produce a symbolic distance effect have been found in a host of real world and experimentally learned categories (Banks, Fujii, and Kayra-Stuart, 1976; Brown and Siegler, 1991; Moyer and Bayer, 1976; Pavese and Ulmita, 1998; Paivio, 1975, 1978ab; Sailor and Shoben, 1993).

Less obvious effects reported in mental comparison studies include a picture superiority effect in non-depictive dimensions (Banks *et al.*, 1976; Paivio, 1978b), congruity and a bowed serial position effect (Shoben, Cech, Schawenflugel, and Sailor, 1989). The amalgamation of these findings shows that any theory of mental comparison tasks needs to explain both the consistency and complexity of the effects across verbal, pictorial, and mathematical dimensions. Two opposing explanations of the findings have been stated (Sailor and Shoben, 1993). The first (a semantic model) claims that the effects arise from the discrete coding of propositionally represented information (Banks *et al.*, 1976). The second account explains the effects in terms of a dual coding model of information representation (Paivio, 1978b). This explanation states that mediated verbal and imaginal systems are invoked in mental comparison judgments (Paivio, 1975, 1978b). It also states that mental comparisons often involve both systems even when the stimuli or dimensions are non-depictive and that the imaginal system is the most effective comparator (Paivio, 1978b).

Figure 8.3. Examples of the Imagery Stimuli Employed in Paivio's Mental Clocks Task (1978a, 1989)



The strongest support for the role of the imaginal system in mental comparison tasks is provided in Paivio's mental clocks task research (1978a). The nature and significance of this task is described by Paivio

"Imagine two clocks showing the times 3.22 and 7.55. On which clock do the hour hand and the minute hand form the smaller angle? This is the basic task used in the present study. It essentially involves a memory size comparison based on one's knowledge about the relation between numerical times and the positions of the hands of a clock. The angular size difference between pairs of times can be determined only by translating the digital information into symbolic representations that preserve angular difference." (Paivio, 1978a, p.61)

The advantage of this task over other relative judgments is that it enables the experimenter to create precise distance levels for comparison. The importance of this task in demonstrating imaginal processing is that it is unlikely that a person would have a semantic knowledge of the hierarchy of angular distances between clocks or that they would be able to perform the task computationally in the time specified (Paivio, 1978a). Furthermore, there is also support for the deliberate use of mental imagery from the self-reports of those performing the task (Paivio, 1978a).

Following a series of experiments Paivio (1978a) claimed that imaginal processing was the only way to explain the symbolic distance effect. He observed that the effect occurred in a purely perceptual analogue model and in an imagery condition where digital times and handless clock faces were shown. He also showed that when the hands for one clock face were removed the reaction times conformed to the hypothesized representational process. Furthermore, it was also observed that individuals with good spatial skills performed the task better than those with poor spatial skills. Combined, these results support the use of imagery processes.

The emergence of standard comparison effects and the self-reports of those carrying out the task suggest that the imagery format version of the mental clocks task provides a good measure of imagery generation, transformation and comparison skill. Furthermore, it should be possible to develop an equivalent mental comparison task that

uses a propositional code. This task could act as a performance measure of non-imaginal mental comparison skill. For example, a propositionally encoded derivative of the mental clocks task could be developed by transposing the digit times into mathematical values. As there is an extensive research literature on mental comparisons in mathematics (Deheane, 1992; Moyer and Bayer, 1976; Pavese and Umiltà, 1998) this is a good alternative measure which can be used to show non-imagery processing abilities.

A review of the research area shows that Paivio's (1978a) stimuli differed from other mental comparison task stimuli that require imaginal processing. This difference concerns the addition of perceptual information. In typical imagery-based comparison tasks the participants are required to create the whole image (Farah *et al.*, 1988). Clearly some image generation is required but the presence of the clock faces means that it is easier to use a mathematical heuristic to solve the mental clocks task. For example, the participants could use the clock time markings as a simple arithmetic device. Though it is unlikely that naive participants would acquire this heuristic, as mathematics tasks produce a very robust symbolic distance effect (Pavese and Umiltà, 1998) it is necessary to modify Paivio's original imagery stimuli. Fortunately this is a relatively simple operation requiring the removal of the clock faces. This has the additional advantage of making this task equivalent to other imagery-based mental comparison tasks (Farah *et al.*, 1988).

In this study it is hypothesized that High Imagers (those who perform above average on the mental clocks task) will perform better than Low Imagers (those who perform below average on the mental clocks task) on the creative visualization task. However, those who perform high on the arithmetic version of the mental clocks task will not perform better on the creative visualization task than those who score low on the arithmetic version. This hypothesis is based upon the assumption that the mental clocks task and the creative visualization task share the same generative and comparative imaging processes.

Method

Participants. Thirty-one female and fifteen male students from Middlesex University volunteered to take part in the experiment. The median age of the participants was 20 with a range of 18 to 41.

Design. A two-way independent groups design was employed to investigate performance on the three creative visualization measures. Participants were randomly assigned to the imagery and arithmetic condition. In the imagery condition they performed the imagery-bound version of Paivio's mental clocks task. In the arithmetic condition they performed a transposed version of the imagery condition. Following the completion of the conditions nested high and low groups were formed from reaction time scores controlled for task accuracy. Three dependent variables were derived from creative visualization task performance.

Materials.

Mental Comparison. The mental comparison tasks were based upon Paivio's mental clocks task (Paivio, 1978a). The imagery condition was developed first and the arithmetic condition was transposed from it.

Twelve clock time trials were selected for each level of the three smallest distances used in Paivio's experiments (30^0 , 60^0 , and 90^0 angle differences). In order to maximize the use of mental imagery in the task the clock faces were removed and only digital times were presented to the individuals. Justification for this procedure is based upon an extensive research literature on distance effects in mathematics (Deheane, 1992). The digital time pairs were balanced for acute angle ratios in the three conditions (for 30 degree distance: 30:60, 60:90, 90:120, and 120:150; for 60 degree distance: 30:90, 60:120, and 90:150; for 90 degree distance: 30:120, and 60:150). The trials were randomly presented on a computer screen with an inter-stimulus interval latency of one second. The trials were counterbalanced for left and right response. The aim of the digit-time only task is to press the response box pertaining to the smallest acute angle between the imagined clock hands.

Figure 8.4. Example Stimuli Used in the Mental Comparison Conditions

Task	Left stimuli	Right stimuli
Imagery	9:50	5:35
Arithmetic	270:300	150:210

An equivalent arithmetic task was developed through the transposition of the imagery clock time pairs. This was achieved by changing the second-hand time into a first-hand time and multiplying the product by thirty (see Figure 8.4). The objective of the arithmetic task is to press the response box that yields the smallest quantity when the smallest number of the pair is subtracted from the largest number of the pair and compared with the same product from the other pair. For example, in the above case the correct response is 'left' as 300-270 produces a smaller product (30) than 210-150 (60). Similarly, the clock time 9.50 produces a smaller acute angle (30°) than the clock time 5.35 (60°). A full listing of the stimuli is provided in Appendix 8.1.

The Creative Visualization Task. The same pencil and paper version of the creative visualization task was used in this experiment as that presented in Chapter Seven. Full details of instruction and scoring procedures are provided in Chapter Seven.

Self-Report Measures. As a secondary source of information 15 visual analogue scales (ranging from 0-100 mm) were developed to measure the participants' self-reported mental abilities and task strategies. Upon arrival the participants completed five self-report measures on: creative ability, mental image generation, arithmetic ability, problem solving skills, and writing ability. In all cases the scales ranged from '*poor*' to '*excellent*'. After completing the mental comparison task the participants rated five more analogue scales. The first of these measured task difficulty (anchored from '*easy*' to '*hard*'). The second measured their self-reported awareness of the processes involved (anchored from '*never aware*' to '*always aware*'). Three measures of general strategy (anchored from '*never used*' to '*always used*') were also completed. These were: verbal comparison strategy, general mathematical comparison strategy, and general mental picture comparison strategy. The final set of analogue scales were presented following the completion of the creative visualization task. These were the same as the scales used for the mental comparison task.

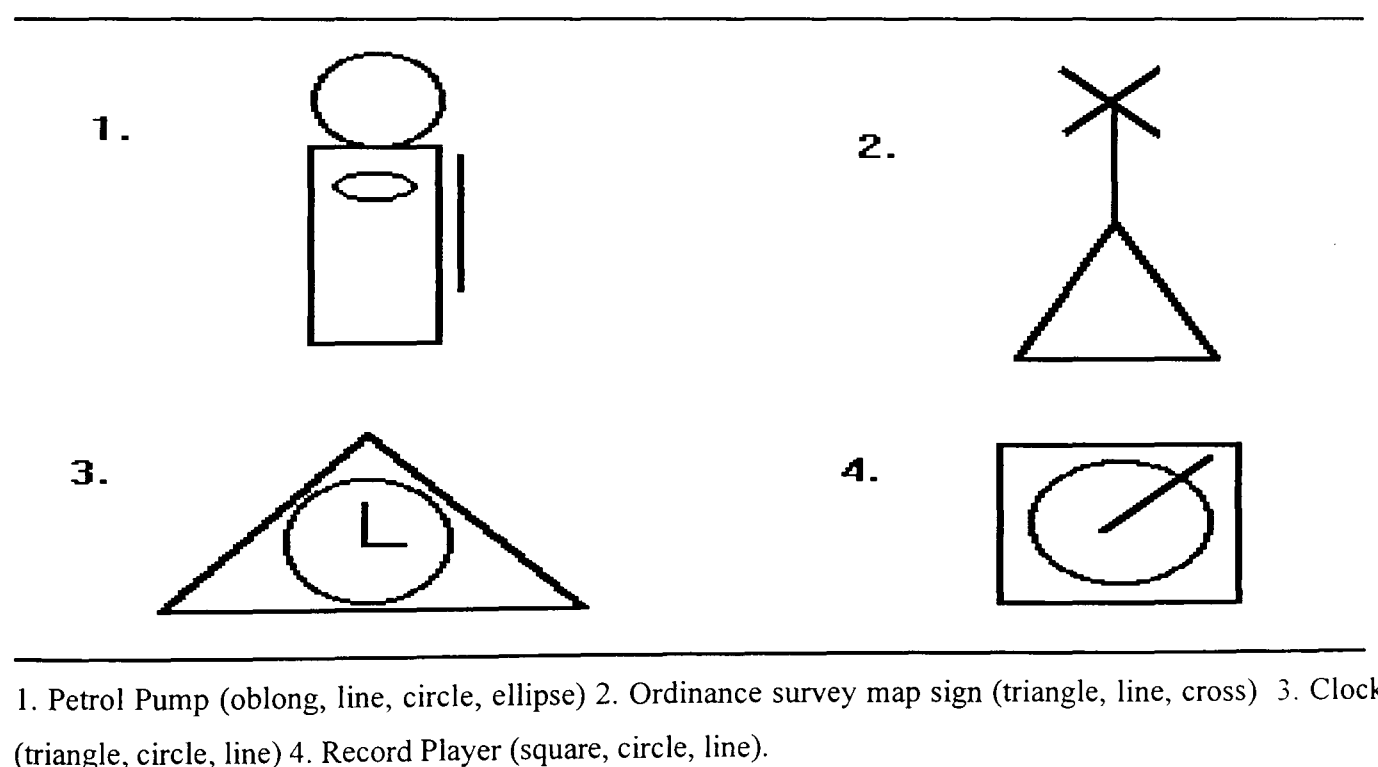
Procedure. Forty-six participants carried out the experiment in a sound attenuated cubicle. They began the experiment by completing the five analogue scales pertaining to their self-reported mental abilities. Once they had been informed of the nature of the reaction time task they were given six practice trials (two from each of the distances). They only proceeded to the experimental conditions when they had successfully completed the six trials. Once the participants had completed the 36 experimental trials

they completed five more visual analogue scales. The participants then completed the test format version of Finke and Slayton's (1988) creative visualization task. Finally, they completed five visual analogue scales pertaining to the creative visualization task.

Results

The Creative Visualization Task. The aim of the study carried out in Chapter Seven was to evaluate the parametric properties of the test-format creative visualization task and the cognitive strategies the participants' report. Further verification of the parametric properties was undertaken in the present study. As the three measures produced good inter-rater reliability they were collapsed and assessed for the usual univariate data screening procedures. Both skew and kurtosis analyses showed that the three measures conformed to the parameters of the standard normal distribution. Furthermore, the scores in the present study were similar to those reported in the previous studies. Examples of creative responses are presented in Figure 8.5.

Figure 8.5. Examples of Responses Scoring High on Correspondence and Rated As Creative In the Creative Visualisation Task.



Reports of difficulty and awareness to solution were similar to those found in the pilot study (see Table 8.3). A repeated measure ANOVA on the participants' self-reported strategies confirmed that mental imagery was the preferred strategy ($F(2,86)=78.24$,

MSe=471, $p<0.001$). Comparisons of self-reports by the pre-tasks (arithmetic and imagery) showed no carry over effects in difficulty, awareness or strategy self-reports (see Table 8.3). When compared to those of the previous study they show consistent responses to knowledge of task performance and strategy employed.

Table 8.3. Self-report Ratings of Difficulty and Strategy in the Creative Visualisation Task by the Two Pre-task Conditions (n=45)

Self-reports	Imagery		Arithmetic		Group Difference
	Mean	St.Dev.	Mean	St.Dev	
Difficulty	80.18	20.93	72.00	24.19	$t(44)=1.21$
Awareness	70.45	26.74	68.00	26.19	$t(44)=0.31$
Verbal strategy	29.95	27.21	25.70	25.46	$t(44)=0.54$
Mathematics strategy	24.32	22.08	18.64	19.11	$t(44)=0.91$
Mental Picture Strategy	72.86	25.93	77.09	16.90	$t(44)=-0.65$

Sex Differences. There is a considerable amount of empirical support for male superiority in many tasks associated with those used in the present study (J.T.E. Richardson, 1999). Independent groups t-tests were conducted on the three measures derived from the creative visualization task. Although the males performed better on all of the measures no significant differences were found (frequency ($t(45)=0.59$, $se=0.91$, $p>0.05$); Correspondence ($t(44)=0.40$, $se=1.88$, $p>0.05$); and, Creativity ($t(44)=1.00$, $se=0.52$, $p>0.05$). An independent groups two-way ANOVA also showed no main ($F(1,42)=0.20$, $MSe=5.44$, $p>0.05$) or interaction effects ($F(1,42)=0.05$, $MSe=5.44$, $p>0.05$) when sex differences were evaluated in the context of mental comparison. Finally, an independent groups t-test showed no differences between males and females on the self-report mental picture measure ($t(44)=1.44$, $se=4.72$, $p>0.05$). In summary sex differences in imagery have not been found.

Self-report Measures of General Abilities. Five independent groups t-tests were carried out to assess mental comparison group differences in self-reported general abilities. The results from these tests were all non-significant (creativity ($t(44)=0.42$, $se=4.68$, $p>0.05$); imagery ($t(44)=-0.37$, $se=4.24$, $p>0.05$); arithmetic ($t(44)=0.45$,

se=5.04, $p>0.05$); problem solving ($t(44)=-1.43$, se=4.94, $p>0.05$); and, writing ability ($t(44)=1.06$, se=4.01, $p>0.05$)). A single self-report measure of the participants' ability to form mental pictures showed good parametric properties and no response leniency ($t(45)=-0.10$, Se=3.34, $p>0.05$).

Mental Comparison Effects. Paivio (1975, 1978ab, 1989) claimed that effects from mental comparison judgments are mediated by verbal and imagery processing systems. Two of these effects (time to completion and the symbolic distance effect) can be predicted from their association with the imagery code. To evaluate these claims a mixed two-by-three ANOVA was employed to assess time to completion and distance. An expected main effect was found for time to completion which supported the belief that the transposition of the clock times reduced latency ($F(1,41)=25.72$, MSe=16.65, $p<0.001$). A non-significant main effect of distance between the stimulus pairs was found ($F(2,82)=2.29$, MSe=0.94 $p>0.05$). Further confirmation of a failure to find the standard distance effect in either of these tasks was confirmed through a non-significant interaction ($F(2,82)=2.73$, MSe=0.94, $p>0.05$). Observation of the reaction times (see Table 8.4) shows no differences between the three distances for the imagery comparison task.

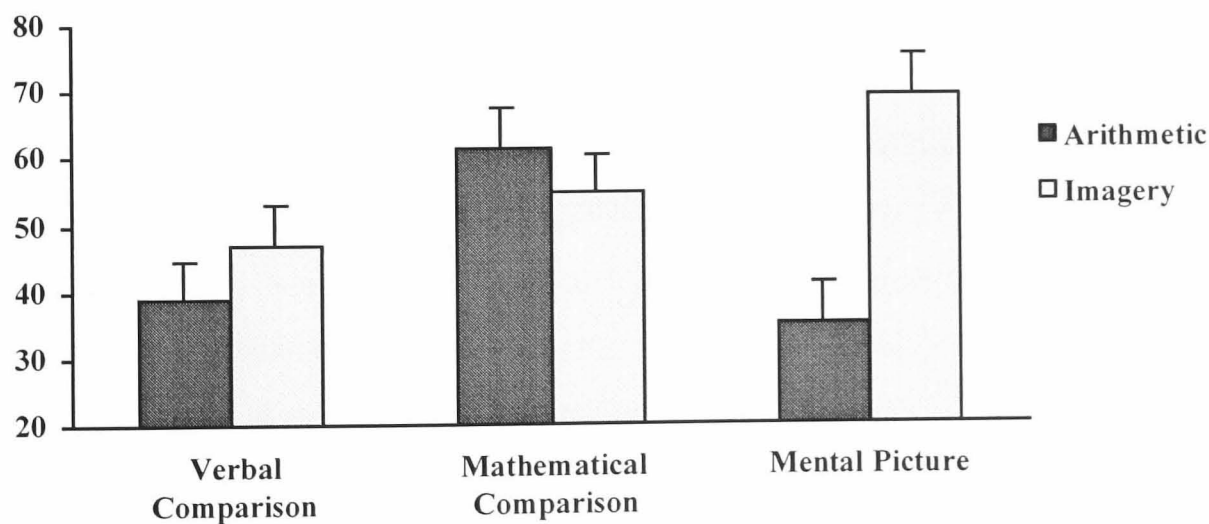
Table 8.4. Reaction Time and The Number of Correct Responses by Mental Comparison Distances in the Imagery and Arithmetic Conditions

	30 ⁰		60 ⁰		90 ⁰	
	Mean	St.Dev.	Mean	St.Dev.	Mean	St.Dev.
Reaction Time						
Imagery (n=20)	9.18	2.27	9.19	2.79	9.25	1.87
Arithmetic (n=23)	6.09	2.80	5.25	2.45	5.32	2.55
Number of Correct Responses						
Imagery (n=22)	9.55	1.34	10.55	1.53	11.00	1.07
Arithmetic (n=24)	9.75	1.89	11.17	1.05	11.04	0.62

Self-Report Measures of Mental Comparison. The self reports concur with the reaction time scores in that the participants in the imagery condition reported a higher difficulty rating than those in the arithmetic condition ($t(44)=2.37$, se=6.72, $p<0.05$). No difference was found in the awareness to solution ($t(44)=-1.01$, se=4.59, $p>0.05$). A mixed

two-way ANOVA was carried out on the two mental comparison conditions by the three self-report strategy measures. These showed that the participants in the imagery condition reported a greater use of strategies *per se* ($F(1,43)=6.72$, $MSe=714.65$, $p=0.01$). It also showed a greater use of a mathematical strategy than an imagery or verbal comparison strategy ($F(2,86)=3.46$, $MSe=777.35$, $p<0.05$). This effect is explained through an expected significant interaction effect ($F(2,86)=6.40$, $MSe=777.35$, $p<0.01$). Simple main effect analyses, with strategies held constant, showed that those in the Imagery condition reported a greater use of a verbal comparison strategy ($F(2,86)=3.26$, $MSe=238.22$, $p<0.05$). There was a non-significant difference in the self-reported use of a mathematics strategy ($F(2,86)=2.35$, $MSe=238.22$, $p>0.05$). Finally, a predicted significant difference was found for the use of a mental imagery comparison strategy ($F(2,86)=55.65$, $MSe=238.22$, $p<0.001$). Mean responses are presented in Figure 8.6.

Figure 8.6. Self-reported Use of Verbal, Mathematical, and Mental Picture Strategies in the Imagery & Arithmetic Comparison Tasks (Range 0mm (“never used”) 100mm (“always used”).



Mental Comparison and Creative Visualization Performance. Despite the mixed findings on the mental comparison task the reaction time scores for the participants were collapsed over distance to yield a single mental comparison performance measure. A median split was used to form high and low groups for the imagery and arithmetic conditions. Mean scores on the three creative visualization measures were then analyzed

using an independent groups two-way design. Mean and Standard deviation scores by groups are presented in Table 8.5.

Table 8.5. Creative Visualisation Task Scores by High and Low Performance Splits for the Two Tasks (Standard Deviations are presented in brackets)

	Frequency	Correspondence	Creativity	Total
Imagery Condition				
High (n=10)	6.50 (2.80)	12.70 (6.23)	1.80 (1.48)	21.00 (10.15)
Low (n=10)	5.80 (2.68)	10.75 (5.95)	1.90 (2.64)	18.45 (10.67)
Arithmetic Condition				
High (n=12)	7.58 (2.82)	13.79 (5.81)	3.08 (1.88)	24.46 (9.52)
Low (n=11)	5.32 (3.34)	10.50 (6.64)	1.36 (1.43)	17.18 (11.44)

Initial analyses employed independent groups ANOVAs for each of the creative visualization tasks. However, as non-significant differences emerged in all cases and the same trend was observed multivariate analyses are provided. A MANOVA was employed to test the hypothesis that those who performed above the median in the Imagery condition would also perform better in the creative visualization task. This hypothesis is based on the assumption that the imagery comparison task and the creative visualization task share the same imaginal processing resources. A non-significant finding for type of comparison task showed that the two groups were similar in their creative visualization skills ($F(3,37)=0.18$, $p>0.05$). Though the high performance groups performed better than the low performance groups a non-significant multivariate effect was found ($F(3,37)=0.89$, $p>0.05$). The interaction between type of comparison task and performance on the comparison task approached significance ($F(3,37)=2.26$, $p<0.1$). However, examination of the scores revealed that those in the high arithmetic performance group performed proportionately better on the creative visualization task than their low arithmetic performance counterparts. No differences were observed between the two imagery groups. These results do not support the main hypothesis.

Discussion

The results from this study confirmed the parametric properties of the test-format creative visualization task. They also showed that consistent self-report responses are given concerning the nature and processing skills required. The mental comparison tasks, however, failed to elicit the behavioural predictors found in previous research into the mental clocks task (Paivio, 1978a). Nevertheless, the self-report measures did offer some support for the use of predicted mental picture and mathematical comparison strategies in these tasks. The main hypothesis, although only significant at the 0.1 level, showed that the high arithmetic group's scores were better predictors of creative visualization performance than the high imagery group's scores. Explanation for this finding is necessarily *post facto*. It could involve the failure to replicate the distance effect, the convergent nature of the imagery comparison task or may simply reflect the superiority of an arithmetic measure in predicting problem solving abilities.

Initial analyses of performance on the creative visualization task demonstrated equivalent findings to those found in the pilot study. The median number of acceptable scores produced was six and approximately 30% of these were rated as creative. The measures also showed good parametric properties.

Assessment of the mental comparison tasks showed that they did not conform to the standard findings in this research area (Shoben, Cech, and Schawenflugel, 1983). These results require further discussion in light of the failure to find an imagery performance indicator of the creative visualization task. The standard linear distance effect has been reported in previous studies using both imagery tasks (Paivio, 1978a) and mathematics tasks (Pavese and Ulmita, 1998). As the response times for the imagery condition were considerably greater than those reported in Paivio's (1978a) clock task the removal of the clock faces might have resulted in a failure to discriminate imagery abilities between individuals. This interpretation is not borne out, however, by the distribution of the scores. These show that the response times had a sufficiently discriminable range (6.68 to 12.71). Furthermore, only one of the participants scored below a 75% correct threshold.

One alternative explanation of why the high imagery group did not perform better on the creative visualization task than the low imagery group is that the convergent nature of the comparison task does not utilize the same transformation procedures required in the

creative visualization task. This explanation, however, is contradicted by the findings from the arithmetic task, which viewed separately account for almost 25% of the variance in the creative visualization task. Surely it would be expected that the subtraction and comparison processes required for this task are as convergent in nature as the imagery task. Furthermore, the participants did not report using mental imagery in the arithmetic task but did report using it in both the mental imagery comparison task and the creative visualization task.

One very tentative explanation for the findings on the arithmetic task is derived from Deheane's triple code model of number representation (Cohen and Deheane, 1991; Deheane, 1992). He argues that numbers can be represented in three translatable codes (Arabic, verbal, and quantity). The third form (quantity) is defined as an analogue magnitude representation. As a preverbal system this number line has been likened to a 'visual workbench' in which the most basic of notational comparisons are performed. This representational code is similar to Paivio's imagery code (Paivio, 1971). Consequently if such a representational code were invoked during arithmetic comparison then it is likely that it would also be employed during the clocks task and the creative visualization task; regardless of the phenomenal status of the processing. However, this explanation would have to account for a first-language preference for calculation in bilinguals and at least some verbal and notation code interfacing (see Deheane, 1992).

In summarizing the findings from the present study it was found that individuals who performed well on a frequently reported mental imagery task did not perform significantly better on the creative visualization task. Explanations for these findings are based firstly on the failure to find a robust distance effect on the imagery comparison task and secondly on the convergent nature of the imagery comparison task. Neither explanation is fitting as both contradict the evidence from the self-report measures. One final account may be that the use of imagery in the creative visualization task requires source demands that are more closely linked to arithmetic processing than was previously conceived. It is more tempting to assume anomaly or artifact before being drawn into such an unproved *post facto* explanation. Only further research will answer the questions raised from this experiment.

General Discussion

Following the development of a test-format version of the creative visualization task it was hypothesized that mental imagery abilities would predict performance on the task. As there had been little research into the role of behavioural predictors of mental imagery in creativity two exploratory investigations were carried out. The first study employed the best known measure of spatial mental imagery (the mental rotation task) and the second used a mental comparison task that could be employed in imagery and non-imagery forms. The results from these studies suggest that the spatial and visual behavioural measures do not directly predict performance on the creative visualization task. Assessments of why these measures failed to predict performance on the creative visualization task have been made in the respective discussion sections.

In Chapter Six a meta-analytic review of the most commonly employed protocol for studying mental imagery and creativity was carried out. It was concluded that the relationship between self-reported mental imagery and divergent thinking performance was not large enough to warrant a theoretical explanation. Having derived small associations between the measures it was decided that new ways and methods of investigating how individual differences in mental imagery could predict performance on a creativity task needed to be implemented. As an alternative method of assessing the relationship between the two variables was available (the image generation approach) a test format version of one of the tasks used within the approach was developed. After a pilot study confirmed that the participants believed that they were using mental imagery to produce composite forms and showed that the test-format version has acceptable parametric properties it was used as a dependent variable in individual differences research carried out in this chapter.

As this new measure of creativity seemed to involve the use of spatial and visual imagery it was hypothesized that performance on behavioural measures of mental imagery may predict how successful the participants were at producing creative and correspondent composite forms. However, the findings from the research carried out in this chapter have been very disappointing. Both latency and accuracy splits on the mental rotation task failed to show the hypothesized individual differences in performance on the creative visualization task. The findings from the mental comparison task are even more disappointing. Not only did the standard distance effect disappear (on which its

hypothesized role in mental imagery was based) following a necessary alteration to the task but the arithmetic alternative was found to be a better predictor of performance on the creative visualization task.

Despite the failure to find the hypothesized differences on the creative visualization task one very positive aspect of the research has been found. This is the finding that the test-format version of the creative visualization task has been shown to yield good parametric responses in all the studies in which it has been employed. Furthermore, as two of the three studies measured the participants' beliefs about how they performed the task it can also be stated that people consistently report using mental imagery in the task. Finally, if the number of creative responses produced from the creative visualization task are viewed in the context of other measures of creativity then it can be concluded that this particular task produces a good proportion of novel responses (Feldhausen and Goh, 1995).

If participants tend to report the use of mental imagery in the creative visualization task and the proportion of creative responses is good when compared to standard divergent thinking tasks then it is puzzling that the measures employed in the present studies failed to support the hypothesized individual difference effect. It could be because the measures employed do not share the same representational processing requirements and that a return to the standard use of self-report measures of mental imagery may provide a better prediction. The finding that participants consistently report the use of mental imagery in the test-format version of the creative visualization task suggests that pursuing a direct prediction from mental imagery measures is worthwhile. However, a closer inspection of Finke's (1990) findings from the creative inventions task also suggests that creative visualization tasks may involve two distinguishable processes (imagery and creative interpretation). This is discussed in further detail in the next chapter.

Conclusion

The research carried out into the test-format version of the creative visualization task has consistently shown that it has good parametric properties and that the participants report the use of mental imagery in the task. However, the results presented in this chapter show that the forms of mental imagery that the mental rotation and clocks tasks are

hypothesized to measure (Paivio, 1989; Shepard, 1984) do not predict performance on this version of the creative visualization task. The evident contradiction between the self-reported use of mental imagery in the task and the results from the two behavioural measures suggests that new ways of thinking about the creative visualization task need to be developed. Perhaps the standard individual differences approach may demonstrate a role for mental imagery in the task. Alternatively it may be that mental imagery plays a necessary (but not sufficient) role in performance on the creative visualization task.

Chapter IX

Study Eleven. The Roles of Imagery and Creativity in Predicting Performance on a Creative Visualization Task

Introduction

The results from Chapters Seven and Eight suggest that the test-format version of the creative visualization task produces good responses that the participants claim are produced from a mental imagery strategy. However, there does not seem to be a role for individual differences in mental rotation and comparison in predicting performance on the task. In this final study in the present series of investigations into the creative visualization task several self-report measures of the vividness of visual imagery are linked with Barron's Symbolic Equivalence Task (SET). The aims of the study are twofold. The first concerns the role of creativity, as measured by the SET, in performance on the creative visualization task. The second focuses upon a possible interaction between imagery and creativity in predicting performance on the creative visualization task.

In considering the results from the previous studies using the test-format version of the creative visualization task it is apparent that the behavioural measures of mental imagery do not seem to be directly linked to performance on the creative visualization task. In considering why this may be it was suggested in the previous study that the creative visualization task may consist of two processes. The first involves the generation and composition of the stimulus parts and the second involves the identification and interpretation of a recognizable composite form. This dissociative process proposition was originally observed and investigated by Finke (1990). In a series of investigations Finke (1990) assessed the relative importance of composite generation and interpretation. The results from these studies showed that some composite forms yielded creative responses regardless of whether mental imagery had been used in the task. However, when the composite forms were developed by the individual (through the use of mental imagery) the number of creative interpretations increased.

It is evident that the same procedure may be deployed in the test-format version of creative visualization task. If this is the case then differences in mental imagery may be masked by the interaction between the two processes involved. As creative responses are produced without the use of mental imagery, then creative interpretation should be the primary predictor of task performance. Mental imagery may be important only when a person is capable of creatively interpreting the composite forms that they have developed. Thus, if this interpretation is correct, then mental imagery ability is insufficient on its own in predicting performance on the task. What is more important is a measure of creative

abilities that involves creative interpretation. The aim of the present study is to investigate the role of both creativity and imagery abilities in predicting performance on the creative visualization task.

In considering a measure of creativity it is clear that the verbal and figural tasks used in the research into the individual differences approach may not be suitable. The main reason for this is that they do not seem to require a creative transformation and interpretation. Rather the form of creativity focuses upon associative and fluency processes (e.g. Hocevar and Bachelor, 1989; Michael and White, 1989). In reviewing alternative measures with similar predictive validity one measure that may require the same generation of creative interpretation is Barron's Symbolic Equivalence Task (Barron, 1988).

As a student of Bartlett, Barron (1988) was influenced by his emphasis upon the relationship between mental imagery and creativity (Bartlett, 1958). Barron (1988) took this knowledge of the inter-dependence of the two variables to the Institute of Personality and Assessment Research (IPAR) where his work with Mackinnon into creativity required further inter-linking between imagery and creative writing (Barron, 1988). In this context Barron developed measures that required the interpretation of verbally presented stimulus images. The measure that evolved (the SET) is an analogical reasoning task that uses highly imageable verbal stimuli. The creative process would therefore seem to be based upon the ability to re-interpret verbally presented stimuli through a mediated imaginal system.

Through his work at the IPAR Barron (1969) was able to evaluate the predictive validity of the SET. In a series of studies he investigated performance on the SET in a range of recognizably creative groups (e.g. famous writers, eminent mathematicians, famous architects, successful entrepreneurs, and student artists). The findings from this research showed that these people scored better than those not recognized in society as creative. Furthermore, it produced a clear rank ordering of creativity that was linked to the general consensus opinion of the creativity of these groups. For example, the famous writers scored better than all of the professions. Famous architects were second placed and eminent mathematicians third. Bottom of these elite groups were the student artists for whom society's creative filter had not yet been imposed. Given the predictive validity of this test and its association with the transformation and interpretation of highly

imageable stimuli the SET seems to be an ideal measure of creativity in the test-format version of the creative visualization task.

As performance on the chronometric behavioural measures of mental imagery failed to predict the frequency, correspondence, and creativity ratings on the creative visualization task it seems an apt time to investigate the role of the self-reported vividness of mental imagery in creativity. Although the results from the earlier chapters suggested that self-report measures can successfully predict creativity to only a limited degree, the creativity tasks employed in these studies were not directly associated with the use of an imagery heuristic. Furthermore, as it has been speculated that there *may* be two processes involved in the test-format version of the creative visualization task the present investigation is concerned with the interaction between the self-reported mental imagery and SET performance.

If the main prediction from the present study is that those who have high self-reported mental imagery and SET scores will perform better than others on the creative visualization task, then it is necessary to develop a dual criterion for group membership. Consequently, a different scoring procedure for the self-report measures of vividness of mental imagery needs to be applied. The procedure adopted in the present study is the same as that used to investigate the behavioural measures of mental imagery, namely, median splits. However, as the factor analytic investigations carried out in the earlier chapters provide valuable information about response averages, the high and low imagery groups can be defined from the larger sample of scores used in the factor analysis.

The aim of the present study is to assess the relative roles of self-reported mental imagery and creativity in the creative visualization task. Justification for considering these variables together is based upon Finke's (1990) observation that although creative responses occur independently of the generation of composite forms, the combination of generation and interpretation produces a proportionately larger number of creative responses. As creative interpretation seems to be a key factor in predicting performance it is also hypothesized that those defined as high in creativity will perform better than those defined as low in creativity. As the participants have consistently reported the use of mental imagery in the test-format version of the creative visualization task, it is tentatively hypothesized that the high imagery group will perform better than the low imagery group.

Method

Participants. Thirty-nine female and twenty-three male undergraduate psychology students at Middlesex University volunteered to take part in the study. The age of the participants ranged from 18 to 45 with a median age of 24.

Design. A two-by-two independent groups design was employed to investigate the role of high and low imagery and creativity in determining frequency, correspondence, and creativity scores on the creative visualization task. High and Low Creatives were derived from a median split on their scores on the Barron Symbolic Equivalence Task (Barron, 1988). High and Low Imagers were defined on the basis of two self-report measures of the vividness of mental imagery. To be defined as a High Imager a participant was required to rate themselves above the average rating (as defined by the factor analytic studies) on *both* of the self-report measures. It was hoped that the use of this more stringent, dual criterion would provide a more reliable division of the participants.

Materials.

The Vividness of Visual Imagery Measures. Two self-report measures of mental imagery were employed in the present study: Marks' eyes-open version of the Vividness of Visual Imagery Questionnaire and The Vividness of Poetry Imagery Questionnaire. Both measures employ a block format linking four items to a specific content (see Chapter Five for further details).

The Symbolic Equivalence Test. The measure of symbolic equivalence developed by Barron (1969) has been adopted in the present task (see Appendix 9.1 for full details). The SET consists of ten stimulus images. At the beginning of the test the participants are told that the aim of the task is to think of metaphors, or symbolically equivalent images, for the stimulus images (up to three responses can be made for each stimulus image). They are then provided with an example stimulus image (*'leaves blown in the wind'*) and three possible responses (*'a civilian population fleeing chaotically in the face of armed aggression'*; *'handkerchiefs being tossed about inside an electric dryer'*; and, *'chips of wood borne downstream by a swiftly eddying current'*).

In the present study the participants received a shortened split-half version of the SET. They were given 10 minutes to complete the task. Each response on the SET is

scored for *aptness* (1-3) and *originality* (4-5); example responses and full directions for scoring are provided by Barron (1988). Total scores are then derived from each participant through the summation of the response scores. In the present study the SET was scored by two judges and as the standard inter-rater reliability correlation coefficient (0.7) was exceeded average scores were computed for each participant.

The Creative Visualization Task. The same test-format version of the creative visualization task was employed in the present study. Total scores were derived for the number of responses, the correspondence of the responses, and the creativity of the responses. Frequency and correspondence ratings for the two raters exceeded a standard 0.7 criterion. Scores for creativity were computed through judges consensus (see Chapter Seven for further details).

Procedure. The participants were initially required to complete the two self-report measures of mental imagery. Once these had been completed they performed the ten minute version of Barron's Symbolic Equivalence Task. Finally, they were given the test-format version of the creative visualization task. The imagery measures took between twenty and thirty minutes to complete. Generally, the tasks were completed within an hour.

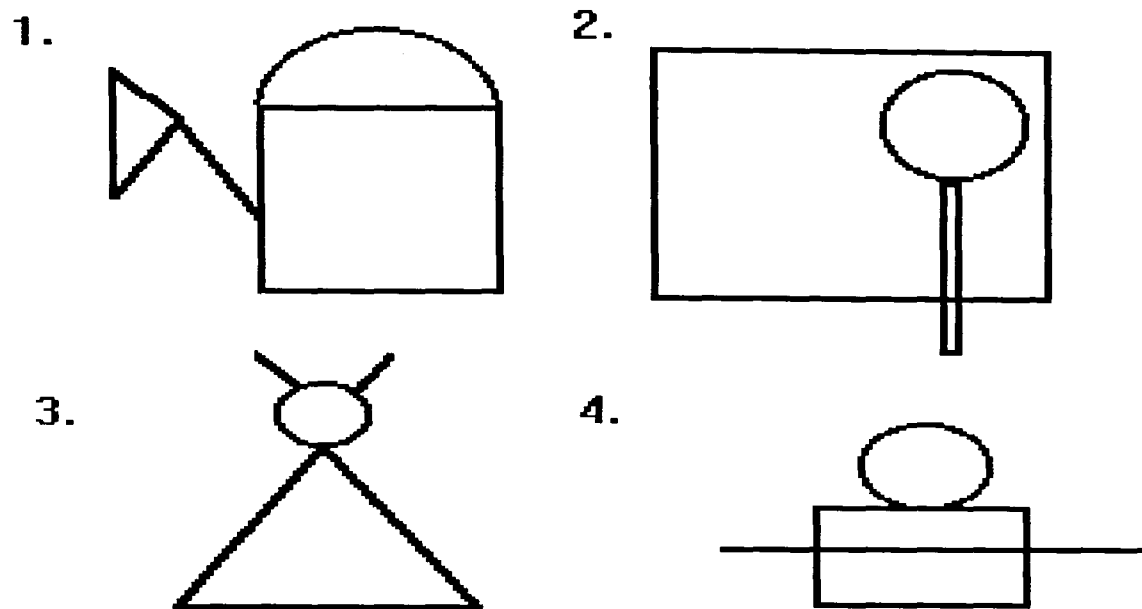
Results

Responses to the three measures of creative visualization were slightly lower than those found in the previous studies. The difference, however, was marginal and may be attributable to the use of different raters. Examples of responses that were rated as high in correspondence and were defined as creative are given in Figure 9.1.

Table 9.1. Creative Visualisation Task Achievement by High and Low Symbolic Equivalence Task Performance.

	Frequency		Correspondence		Creativity	
	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.
SET High (n=32)	6.30	2.88	13.72	7.08	1.44	1.39
SET Low (n=30)	4.00	2.12	8.40	5.15	0.67	0.88
Total	5.19	2.78	11.15	6.73	1.06	1.23

Figure 9.1. Responses Rated as High in Correspondence and Creativity on the Creative Visualisation Task.



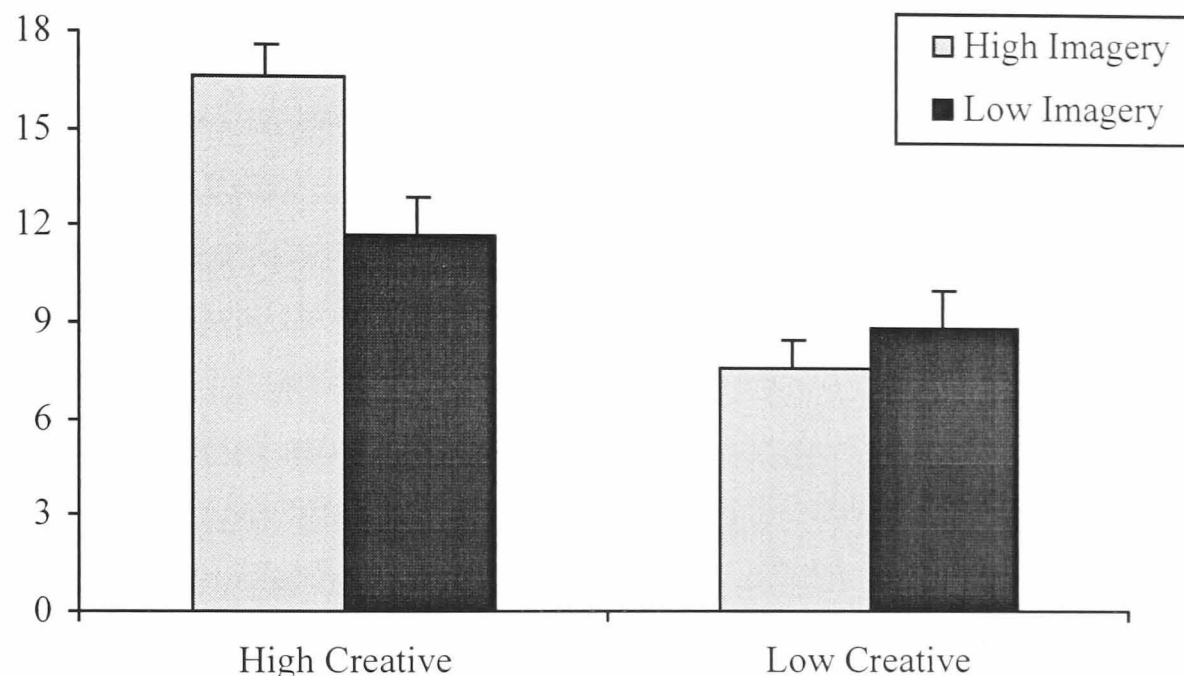
1. Watering can (triangle, line, square, semi-circle) 2. Cooking (square, circle, oblong) 3. Moth (line, line, circle, triangle) 4. Canoeist (circle, square, line).

The average collated score for the SET was 12.52 with a range of 0 to 28.50. A median split (12) was computed and high and low creativity groups were formed. High and low imagery groups were derived from a profile of their scores on both of the vividness of visual imagery self-report measures. Twenty-four of the participants were defined as High Imagers because they scored below the median on both of the imagery measures. Of these, 13 scored above the median on the SET (High Imagery-High Creativity) and 11 scored below the median on the SET (High Imagery-Low Creativity). The remaining 38 participants scored above the median on one or both of the imagery measures. Half (19) scored above the median on the SET (Low Imagery-High Creativity) and half (19) scored below the median on the SET (Low Imagery-Low Creativity).

The effects of self-reported mental imagery and SET performance on the creative visualization task were assessed through a series of two-way independent groups ANOVAs. Analyses of the frequency measure showed a significant main effect for creativity ($F(1,58)=13.84$, $MSe=6.39$, $p<0.001$). Observation of the differences (see Table 9.1) shows that those defined as high in creativity performed better than those defined as low in creativity. Although the High Imagers performed slightly better than the Low Imagers a non-significant difference was found between the two groups ($F(1,58)=1.07$,

MSe=6.39, $p>0.05$). Although the high imagery-high creativity group performed better than the other three groups a non-significant interaction effect was observed ($F(1,58)=1.56$, MSe=6.39, $p>0.05$). In summarizing these findings it is concluded that those defined as high in creativity on the SET produce more responses on the CVT than those defined as low in creativity on the SET.

Figure 9.2. Mean Correspondence Ratings on the Creative Visualisation Task (Y-Axis) Split by High and Low Imagery and Creativity Groups



A further two-way independent groups ANOVA was performed on the correspondence rating scores for the imagery and creativity factors. A main effect of creativity was found ($F(1,58)=14.18$, MSe=36.60, $p<0.001$). Observation of the means showed that those who scored high on the SET performed better on the CVT than those who performed low on the SET. A non-significant difference was found for the imagery conditions ($F(1,58)=1.38$, MSe=36.60, $p>0.05$). There was, however, a significant interaction between imagery and creativity ($F(1,58)=3.87$, MSe=36.60, $p<0.05$). Simple main effect analyses showed that those who reported high imagery and performed high on the SET performed significantly better on the CVT than those who reported low imagery and performed high on the SET ($F(1,58)=5.51$, $p<0.05$). Conversely, a non-significant difference was found between the high imagery-low creativity group and the low imagery-low creativity group ($F(1,58)=0.31$, $p>0.05$). Further simple main effects analyses, where the imagery groups were held constant, showed a significant difference

between the high imagery-high creativity group and the high imagery-low creativity group ($F(1,58)=13.37$, $p<0.001$) and a non-significant difference between the low imagery-high creativity group and the low imagery-low creativity group ($F(1,58)=2.09$, $p>0.05$). Collectively these results show that although performance on the SET is fundamental to predicting performance on the CVT the combination of imagery and SET performance is the best predictor of CVT correspondence performance (see Figure 9.2).

A final ANOVA on the creativity measure of the CVT confirmed the finding that SET performance is a good predictor of CVT achievement ($F(1,58)=8.40$, $MSe=1.33$, $p<0.01$). It also showed that the imagery factor does not yield significant differences in CVT performance ($F(1,58)=1.08$, $MSe=1.33$, $p<0.05$). Finally, the same trend as that observed for the correspondence ratings was found for the interaction between imagery and creativity. However, the findings failed to show a significant interaction between the imagery and creativity factors ($F(1,58)=2.80$, $MSe=1.33$, $p<0.1$).

Discussion

The aim of this study was to investigate the roles of creativity (as defined by SET performance) and self-reported mental imagery in performance on the creative visualization task. Having found that the creative visualization task scores conformed to the previous findings high and low imagery and creativity groups were formed. Factorial independent groups analyses showed that the creativity scores consistently predicted performance on the creative visualization task. The imagery groups consistently showed non-significant differences. However, there was a general trend of imagery and creativity mediation in predicting performance on the creative visualization task. Although this trend did not reveal significant findings for the frequency measure it approached significance on the creativity scores and was firmly established on the correspondence ratings for the creative visualization task.

Previous research had detected a two-phase process in the production of composite forms on the creative visualization task (Finke, 1990). The most fundamental process inferred from this research was the creative interpretation of pre-inventive composite forms. Thus, the ability to interpret and translate image forms appears to be an essential aspect of the creative visualization task. In the present study a measure of creativity (the Symbolic Equivalence Test) that involved the re-interpretation of verbal

stimuli was employed to assess the role of creative interpretation. Following the derivation of high and low creativity groups analyses showed that performance on the creativity task consistently predicted scores on the three creative visualization task measures. These findings collectively support a role for creative interpretation in the creative visualization task. They also reinforce the observation that even in tasks that seem to require imagery processing ratings of the vividness of mental imagery are not a sufficient predictor of performance.

Having established a paper and pencil version of the creative visualization task, the main focus of this chapter, and the preceding chapter, has been upon the role of mental imagery in predicting performance on this version of the task. However, previous studies failed to show a role for the mental comparison and rotation of images in the creative visualization task. As a general failure to predict performance on the task was observed, this study assessed self-reported mental imagery in the context of a creative interpretation measure. Results showed that this imagery measure failed to independently predict performance on the creative visualization task. However, when the measure was assessed in the context of the creativity task, it was shown that imagery plays an important mediating role in performance on the creative visualization task.

The results from the present study suggest that the role of mental imagery in the creative visualization task is dependent upon the individual's ability on a creativity task. The findings from the correspondence ratings show that the combination of high imagery and high creativity results in a greater score than low imagery and high creativity. Thus, although a high creativity score may in itself be a sufficient predictor of performance, a high imagery score is not. This is especially pertinent as the group that scored lowest were those who defined themselves as high in mental imagery but performed below average on the creativity measure.

As these findings have tentatively unmasked a role for mental imagery in creativity they raise further questions about the findings from the previous research using mental comparison and letter rotation tasks. The findings from the self-report measures of imagery were similar to those found in the earlier studies of the role of mental imagery in the creative visualization task. Assessing the roles of spatial imagery in the context of the SET may also provide useful information about the use of mental imagery in creativity. As self-report measures do not predict performance on behavioural measures of spatial

imagery (Di Vesta *et al.*, 1971; Hiscock, 1978; and, McKelvie and Rohrberg, 1978) this may prove to be a particularly fruitful area of investigation. Such an investigation could involve a further distinction of imagery abilities into the visual and spatial formats variously supported by previous researchers (Farah, Hammond, Levine, and Calvanio, 1988; Harshman and Paivio, 1987; Kosslyn, 1994; and, Logie, 1986, 1995; Logie and Marchetti, 1991). These may provide useful information about the respective roles of generation, transformation and synthesis.

Conclusion

Previous studies into the role of mental imagery in the creative visualization task have failed to support the contention that imagery plays an important role in the task. As this failure may be attributed to the distinguishable roles of generation and interpretation in the task a measure of creativity was employed in the present study. Analyses of the results showed that the creativity measure consistently predicted performance on the creative visualization task. The results also supported a role for mental imagery, as mediated by performance on the creativity task. Future research should further assess the roles of transformation and integration of stimulus parts in the creative visualization task.

As the present study has shown that imagery plays a mediating role in performance on the test-format version of creative visualization task, the final studies presented in the thesis turn to the third aspect of mental imagery and creativity outlined in Chapter Three. These studies, based upon the contention that mental imagery interacts with perception in creativity, investigate the role of mental imagery in creativity under conditions of perceptually congruous and incongruous information.

Chapter X

Mental Imagery, Creativity & Perception

General Introduction

The empirical research carried out in the thesis has amalgamated the two main experimental approaches to the study of mental imagery and creativity. Although the findings have provided further information about the role of mental imagery in creativity, they have not addressed the obvious disparity between empirical and anecdotal enquiry described in the first three chapters. The aim of this final empirical chapter is to partially address this disparity and to propose a new framework for investigating the role of mental imagery in creativity. Fundamental to this method is the hypothesised interaction between perceptual and imaginal processes in determining the significance of imagery in creativity (Flowers and Garbin, 1989). Two experiments are carried out in which the role of perceptually congruent and incongruent information is addressed in the context of individual differences in mental imagery and creativity.

In the previous chapters the principal methods for investigating the role of mental imagery in creativity (the individual differences and image generation approaches) were assessed and investigated using an individual differences protocol. The dominant method of investigating the relationship between the two variables was evaluated through further studies and meta-analytic reviews. It was concluded that self-reported mental imagery predicts performance on standard divergent thinking tasks but new methods of investigation are required to make this prediction empirically relevant.

The failure to find an empirically relevant predictor of creativity led to further investigation in which behavioural measures of mental imagery were used to predict performance on a creativity measure derived using the image generation approach (Finke and Slayton, 1988). As differences in latency and accuracy on spatial and visual behavioural measures of mental imagery did not predict performance on this task a final study investigated the role of high and low imagery and creativity groups in creative visualisation performance. This study showed that the vividness of mental imagery is important in predicting performance on the task. However, this role is only effective when an individual performs well on a measure of creative re-interpretation (Barron's SET). Thus, mental imagery seems to be a necessary but not a sufficient predictor of performance on the test-format version of the creative visualisation task. In assessing the results from this research it is concluded that while mental imagery has been shown to

play a role in creativity, there still remains a disparity between the empirical research findings and the anecdotal reports of historically creative individuals. A new method of enquiry may be necessary for further progress to be made.

The main tenet of the present chapter is that the role of mental imagery in creativity (and in information processing in general) needs to be understood in the context of perceptual processing. Converging lines of evidence in mental imagery research suggest that perceptual processes can both interfere with and facilitate imaginal processing in cognitive tasks (Craver-Lemley and Reeves, 1992; Farah, 1985; Logie, 1986; Sobel and Rothenberg, 1980; Zubek, 1969). Furthermore, many of the anecdotal reports of the role of mental imagery in historical creativity suggest that the association between the two variables is strongly linked to environments in which perceptually incongruent information is inhibited or decreased (Daniels-McGhee and Davies, 1994; Ghiselin, 1952; Mavromatis, 1987; Ochse, 1991; Partington, 1964; Rothenberg, 1995).

The aim of the following studies is to assess the mediatory role of perceptual processing in predicting performance on a creativity task. In the first study a perceptual competition hypothesis is tested. In this approach the role of imagery in creativity is hypothesised to become more pertinent in environments that lack perceptually incongruent information. In the second study an alternative aspect of the imagery-perception link is investigated through a study of verbally sourced and perceptually sourced creativity tasks. It is hoped that these studies will demonstrate the importance of perceptual mediation in mental imagery and creativity. In keeping with the overall theme of the thesis, the significance of mental imagery in creativity is assessed through an individual differences protocol.

Study Twelve. The Role of Mental Imagery Abilities in Creativity Under Perceptually Isolated and Interference Conditions

Introduction

The classification of mental images provided in Chapter Three suggested that the role of mental imagery in historical creativity is reported more frequently in conditions and circumstances defined by the author as ‘dream-associated’. This was further supported by the many anecdotal reports given throughout the thesis and the citation count

in Chapter Four which showed that the most common accounts of imagery and creativity occur in dreaming, hypnagogic, and daydreaming states (Daniels-McGhee and Davies, 1994; Feldman, 1988; Ghiselin, 1952; Kerr, 1993; Mavromatis, 1987; Paivio, 1983; Shepard, 1978a).

Aside from their ‘dream-associated’ status a fundamental characteristic of many of the theories put forward to explain the states in which these mental images occur is the competition between perceptual and imaginal processing. For example, Hobson (1988) argues that the predominance of dream images results from a sensory-input blockade. Similarly, Singer’s (1975) account of daydreaming posits a model of competing internal and external source demands. Hilgard (1992) claims that hypnotic phenomena arise from the suppression and dissociation of the reality monitor. Suler (1980) emphasises the emergence and dominance of preverbal primary process thinking during meditation. Mavromatis (1987) notes the importance of autonomous hypnagogic visual phenomena and Zubek (1969) reports the proliferation of reported visual experiences in perceptually isolated conditions. Thus, accounts of the states in which mental images are most frequently associated with historical creativity suggest that the inhibition of perceptual processes enhances imagery (Zuckerman, 1969). This view is further supported by Flowers and Garbin’s (1989) review of the roles of perception and imagery in creativity. As they state:

“Because documented self-reports of mental events associated with creative thought often include extensive use of mental imagery it seems plausible that creating an environment that minimises potentially interfering sensory input might be useful in facilitating manipulations of mental image processing and, hence, contribute to creative thought.”

(Flowers and Garbin, 1989, p.152).

These theories and accounts of the ‘dream-associated’ states in which so many anecdotal accounts of historical creativity have been reported suggest that there may be a fundamental association between perceptual, imaginal, and creative processing. However, despite frequent references to these anecdotal reports, researchers have neglected to investigate the probable interaction between the three processes.

Perceptual Interference

Early studies of interference effects were carried out at the beginning of the century by Scripture, Keulpe, and Perky (Craver-Lemley and Reeves, 1992). The most well known example of imagery interference was reported by Perky in 1910 (Richardson, 1969). Perky found that participants failed to report the existence of supra-liminal stimuli whilst imaging. The results of this research have since been replicated in a range of experimental protocols (Craver-Lemley and Reeves, 1987, 1992; Segal and Fusella, 1970). The findings suggest that an instruction to use visual imagery produces a lowering in the perceptual sensitivity threshold (Craver-Lemley and Reeves, 1992).

Although imagery interference studies are theoretically important they do not show that perception interferes with imaging. Research into perceptual interference has evolved from the short-term memory research reviewed in Chapter Three. The experimental protocol (derived from a series of studies carried out by Brooks, 1967) tests participants performance on imagery and non-imagery memory tasks following a concurrent visuo-spatial task. The effects of perceptual disruption were thoroughly investigated in a series of studies carried out by Logie (1986). He showed decrements in mnemonic task performance even when the concurrent perceptual stimuli was unattended. The findings from this research suggest that imagery processing in memory tasks is as susceptible to visuo-spatial interference effects as verbally rehearsed material is susceptible to articulatory suppression (Baddeley, 1997).

Environments that Enhance Imaginal & Creative Processes

The research presented thus far offers tentative support for the notion that the use of mental imagery during test-format divergent thinking tasks is disrupted by incongruent perceptual competition. However, research into imagery mnemonics shows that these tasks can be performed perfectly well in test-room formats. It is only when the participants are required to perform a concurrent task that competition exerts an effect. Furthermore, the research carried out in the previous Chapter showed that people were capable of generating creative composite forms from stimulus parts. This research suggests that people can use imagery to perform tasks in test-room environments.

It may be true that imagery can be employed in these tasks but the anecdotal reports of historical creativity suggest that imagery may be enhanced in environments that

either suppress or have minimal sensory information. The conclusion from the review (in Chapter Three) of mental images and creativity showed that mental images were more likely to be implicated in the creative process when they occurred in 'dream-associated' states. Furthermore, this was especially so when the individuals did not report a 'special' form of imagery (e.g. synaesthesia).

The review in Chapter Three also highlighted the general failure to empirically verify the role of 'dream-associated' mental images in creativity. This is probably due to the problem of implementation. In many circumstances it is not possible to construct an experimental environment that is capable of evaluating the role of these altered states of consciousness in creativity (e.g. dreaming and hypnagogia). Furthermore, even in the non-somnambulistic 'dream-associated' states there is a problem with the implementation of psychometric tests of creativity. However, there is one condition in which it may be possible to employ a creativity measure. This is under conditions of short-term restricted environment stimulation (REST).

A literature review of sensory deprivation research shows that there was an intense period of investigation between 1954 and 1969. This was followed by less interest in long-term sensory deprivation and the introduction of short-term perceptual invariance studies (Suedfeld, Steel, Wallbaum, Bluck, Livesey, and Caposzzi, 1994). The new direction of research has focused upon the beneficial effects of short-term sensory deprivation (Suedfeld, 1980; Suedfeld and Best, 1977; Suedfeld and Clarke, 1981; Suedfeld, Metcalfe, and Bluck, 1987). Recent research into sensory deprivation has used very short duration tasks in floatation chambers. As was noted, these studies have investigated the positive effects of the restricted environmental stimulation technique (REST). The emphasis upon the beneficial effects of REST has led several researchers to investigate its role in creativity. A study by Suedfeld *et al.* (1987) found that individuals reported having more creative ideas during floatation than a perceptually variant room isolation. Furthermore, a later study by Forgays and Forgays (1992) reported improved performance on Guilford's creativity scale following floatation. Earlier, a study by Tushup and Zuckerman (1977) found enhancements in creativity following a stimulus invariance procedure.

As the study reported by Suedfeld *et al.* (1987) did not use a psychometric test, it provides a limited amount of support for a perceptual competition hypothesis. The other

experiments demonstrate an increase in divergent thinking abilities following short-term sensory deprivation. However, as these studies did not provide the participants with divergent thinking tests during the sensory deprivation period it cannot be concluded that an enhancement in creativity resulted from perceptual isolation. Furthermore, as the studies did not take measures of mental imagery, it cannot be assumed that the increase in divergent thinking was attributable to a decrease in perceptual processing in those with high mental imagery abilities.

The aim of the present study is to investigate the role of concurrent restricted environmental stimulation in the creativity performance of high and low mental imagery groups. This will be carried out through the presentation of creativity tasks in restricted and focused environments. As the aim of the experiment is to assess the effects of concurrent perceptual isolation, presenting the creativity tasks in their standard written format may disrupt the experiment (Brooks, 1967). To minimise the effects of perceptual interference, the stimuli are presented in an oral mode during the perceptual isolation phase and in a written form following the perceptual isolation phase.

Method

Participants. Twenty-six undergraduate Middlesex University students volunteered to take part in the study. The sample consisted of 20 females and 6 males with an age range of 18-47 and a median age of 24.5 years.

Design. A mixed design was employed in which the two dependent variables (SET performance in oral and written modes) were assessed separately. High and low imagery groups were derived from a median split on the two self-report measures of the vividness of mental imagery. The environment factor consisted of two conditions, a perceptual isolation environment and perceptual focus environment. Counterbalancing was used to control for possible carry-over effects in environment and split-half SET.

Materials. The Symbolic Equivalence test is fully defined in Barron (1988). Full details of the SET are presented in Chapter Nine (see Appendix 9.1). In the present study a split-half procedure was employed in which participants performed each half of the SET twice, once in an oral mode and once in a written mode. The VVIQ and the VPIQ versions used in the present study were identical to those presented in Chapter Five with

the exception that the participants were informed that they could perform the task with or without their eyes-open.

Procedure. Following completion of the two self-report measures of mental imagery the participants performed the experimental component of the study. The participants performed the split-halves in two environment conditions. There was an interval of a week between the two phases of the experiment. In the perceptual isolation environment the participants were taken to a sound and light proof room. The participants were informed that they would be required to perform the SET following 20 minutes of perceptual isolation and were given the instructions to the SET. Following the first perceptual isolation phase they were presented with the SET in an oral mode (through a P.A. system) and their responses were recorded. After they had completed the SET they remained in the perceptual isolation environment for a further 20 minute period. After the second perceptual isolation phase a sufficient amount of light was provided to enable them to complete a written version of the SET. The perceptual focus condition was carried out identically to the perceptual isolation condition with the exception that between the presentations of the SET lighting was not restricted and they were required to attend to a video recording presentation.

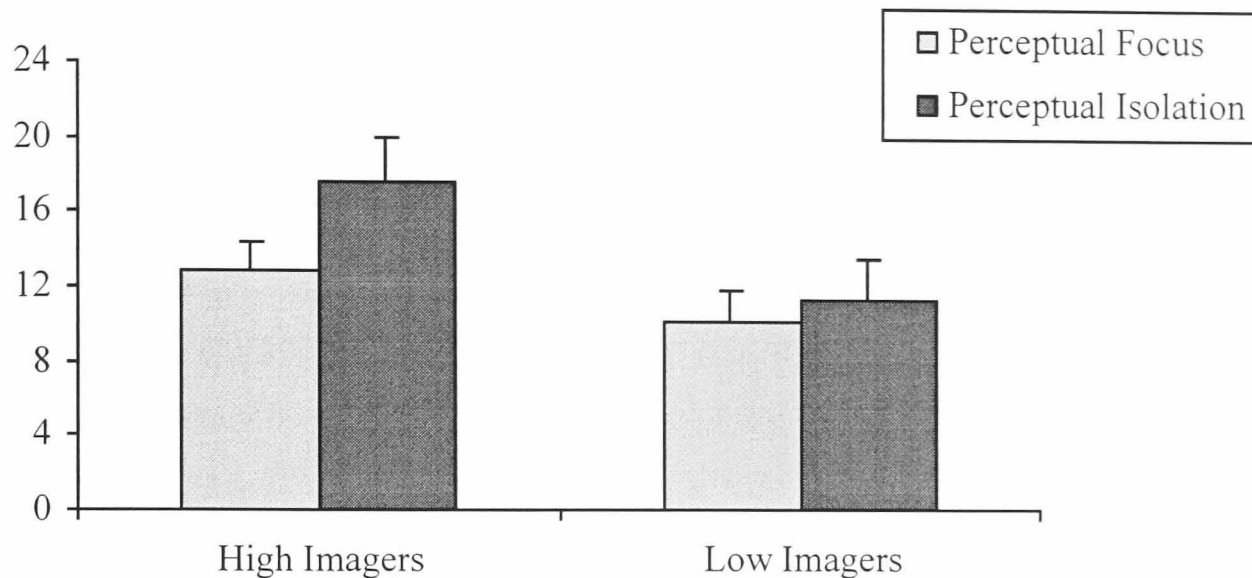
Results

The SET was blind-rated by two judges using the procedure outlined by Barron (1988). As inter-rater reliability coefficients exceeded 0.8 a combined score was obtained. Separate analyses for order ($F(1,24)=2.33$, $MSe=91.63$, $p>0.05$) and split-half ($F(1,24)=0.96$, $MSe=96.67$, $p>0.05$) showed no significant effects.

Oral Mode of Presentation. Analyses of performance on the SET were carried out independently for mode of presentation because the participants were performing the task a second time in the written mode of presentation (see Figure 10.1). A mixed ANOVA was carried out where the self-reported high and low mental imagery groups performances on the SET were assessed in the context of the perceptual conditions. Although the participants in the high imagery group performed better than those in the low imagery group the imagery factor was not significant at the conventional alpha level ($F(1,24)=3.59$, $MSe=73.03$, $p<0.1$). A significant main effect for the type of environment factor showed that that both groups performed better in the perceptual isolation condition

($F(1,24)=4.74$, $MSe=23.34$, $p<0.05$). Finally, although the high imagery group showed a relatively larger increase in performance in the perceptual isolation condition a non-significant interaction was found ($F(1,24)=1.97$, $MSe=23.43$, $p>0.05$).

Figure 10.1. Mean SET Scores in the Oral Mode of Presentation For High and Low Imagers in Perceptually Focused and Isolated Environments (With Standard Error Bars)

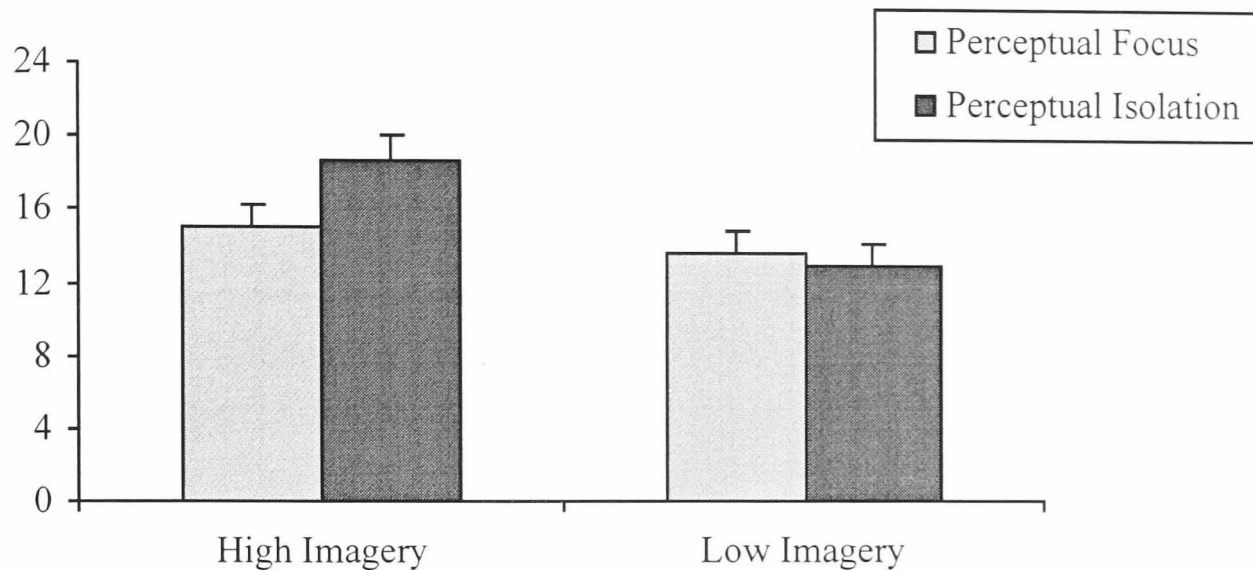


Written Mode of Presentation. A mixed ANOVA was also employed to assess the effects of environment and imagery on performance in the written version of the SET (see Figure 10.2). A main effect of imagery showed that the high imagery group performed significantly better than the low imagery group ($F(1,24)=5.20$, $MSe=32.22$, $p<0.05$). Although the effect of environment approached significance ($F(1,24)=2.94$, $MSe=8.67$, $p<0.1$) observation of the scores shows that the difference observed between the two environments needs to be understood in the context of a significant interaction between environment and imagery ($F(1,24)=7.46$, $MSe=8.67$, $p<0.01$).

As the mixed ANOVA revealed a significant interaction between the environment preceding the task and the participants' self-reported mental imagery, simple main effects analyses were conducted in which the levels of each factor were held constant. These showed that the high imagery group performed significantly better on the perceptual isolation condition than on the perceptual focus condition ($F(1,24)=10.71$, $MSe=8.67$, $p<0.01$). However, there was not a significant difference between the environment conditions for the low imagery group ($F(1,24)=0.48$, $MSe=8.67$, $p>0.05$). Similarly the

high imagery group performed significantly better than the low imagery group in the perceptual isolation condition ($F(1,24)=10.78$, $MSe=20.43$, $p<0.01$) but not in the perceptual focus condition ($F(1,24)=0.59$, $MSe=20.43$, $p>0.05$).

Figure 10.2. Mean SET Scores in the Written Mode of Presentation For High and Low Imagers in Perceptually Focused and Isolated Environments (With Standard Error Bars).



Discussion

The results from this study concur with the previous research carried out into the role of mental imagery in creativity and also support the hypothesis that mental imagery abilities are predictive of performance on a creativity task when incongruent perceptual information is restricted. Analyses of both the oral and written modes of presentation showed that high imagers did not perform better than low imagers in the standard perceptually variant environment. However, the results from the written mode of presentation showed a significant difference in performance between High and Low Imagers in the perceptual isolation condition. Overall, the findings suggest that the use of mental imagery abilities in creativity is dependent upon the environment in which the task is performed.

Previous research into creativity following short-term sensory deprivation periods had shown that people benefited from the effects of isolation (Forgays and Forgays, 1992; Tushup and Zuckerman, 1977). Explanations for the improvement varied. Forgays and Forgays (1992) suggested that improvements in creativity following floatation may be the

result of a reduction in depression and an increase in vigour. Tushup and Zuckerman (1978) explained their findings in the context of daydreaming and fantasy differences. As previous research has shown that self-reported mental imagery correlates with daydreaming (Bowers, 1978; Glisky *et al.*, 1995; Wallace *et al.*, 1994) the present findings concur with Tushup and Zuckerman's (1977) conclusion.

Future research into the role of perceptual isolation in predicting performance on creativity tasks should further assess the relationship between daydreaming, fantasy proneness and self-reported mental imagery vividness. Ideally an independent groups design could be developed which successfully differentiates people on these variables. The findings from this research could be used to discern the respective roles of the fantasy proneness and self-reported mental imagery. They may also verify the findings from this initial study into the inhibition of imagery differences in creative performance during perceptually variant environments. However, the final study in the thesis takes an alternative approach. The aim is to address several anomalies arising from the general mental imagery literature in the context of the roles of perception and imagery in predicting performance on a creativity task.

Study Thirteen. The Role of Verbally Sourced Mental Imagery Abilities in Creativity in Perceptual and Verbal Sourced Versions of the SET

Introduction

In the previous study it was shown that self-reported mental imagery abilities predicted performance on the symbolic equivalence task when the participants were in a perceptual isolation environment but not when they were in a perceptual focus environment. Having shown that perception may play a mediating role for mental imagery in creativity, the final study in the thesis investigates further ways in which perception may interact with mental imagery in predicting performance on creativity tasks. The area of interest in this study is the way in which perceptually congruent information may facilitate performance on creativity tasks.

One way in which mental imagery protocols could be categorised is on the basis of their interaction with verbal or perceptual representations. A particular feature of the best known and most frequently applied mental imagery protocols is that the mental

images are derived from perceptual representations. The majority of spatial imagery tasks involve the interaction between perceptual and imagery processes. For example, Shepard's (Shepard and Metzler, 1971) mental rotation task necessarily involves the perceptual identification of two three-dimensional forms prior to any spatial transformation. Similarly, Kosslyn's (Kosslyn *et al.*, 1978) mental scanning task involves an initial perceptual representation of the to-be-scanned material. Thus, although these tasks are collectively referred to as measures of spatial imagery they are also perceptually sourced tasks.

Conversely, there are many tasks which do not use perceptual representations as source material. Many of the self-report measures of mental imagery require the participants to create mental images from a verbal source (Marks, 1973; Richardson, 1969; Sheehan, 1967). Many of the mental comparison tasks also involve the generation of mental images from verbal stimuli (Moyer and Bayer, 1976). Finally, Paivio's (1971) paired-associate learning tasks are also based upon the interaction between verbal and imagery processes.

Curiously this distinction between mental imagery protocols has not been sufficiently investigated by researchers predicting localisation of image generation (Sergent, 1990). However, if the results from the previous experiment are taken into account, then the mediating role of perceptually sourced material may be important in accounting for the role of mental images in creativity. This is especially relevant given one conclusion drawn from Chapter Two, namely, that if mental images play a role in creativity, then there needs to be a clear distinction between mental images and percepts.

While the results from the individual differences research carried out in Chapter Six failed to show any difference between figural and verbal versions of the TTCT, these tasks were also shown to be of little value to an understanding of the role of mental imagery in creativity. As the SET (Barron, 1988) has been shown to be a useful predictor of the role of mental imagery in creativity, the aim of the present study is to develop a perceptually sourced version of the task. That is, to produce accompanying perceptual representations of the stimulus images that constitute the task.

The immediate question that arises is, how would high and low self-reported mental imagery groups perform on the two tasks? The results from the previous study suggest that reducing perceptually incongruent information results in increased

performance in High Imagers but not Low Imagers. In the present study, however, it would be expected that Low Imagers would benefit more from perceptually sourced material. This is because they are provided with an additional source of information from which to create symbolic equivalencies. Conversely, the High Imagers report being able to generate images from a verbal source, so the perceptual information may prove to be a hindrance because it competes with rather than facilitates imaginal processes.

Method

Participants. Twenty-four female undergraduate psychology students at Middlesex University took part in the experiment as part of a course requirement.

Design. A mixed factorial design was employed to assess the effects of perceptual facilitation and self-reported mental imagery ability in performance on the SET. The participants were given split-half versions of the SET. In the standard condition they were presented with written stimulus images and in the perceptual facilitation condition they were given written stimulus images accompanied with a pictorial representation (see Appendix 10.1). The participants were divided into low and high imagery groups on the basis of a standard median split on two measures of the self-reported vividness of mental imagery. The dependent variable was the score on the SET. The conditions were counterbalanced for order and split-half presentation.

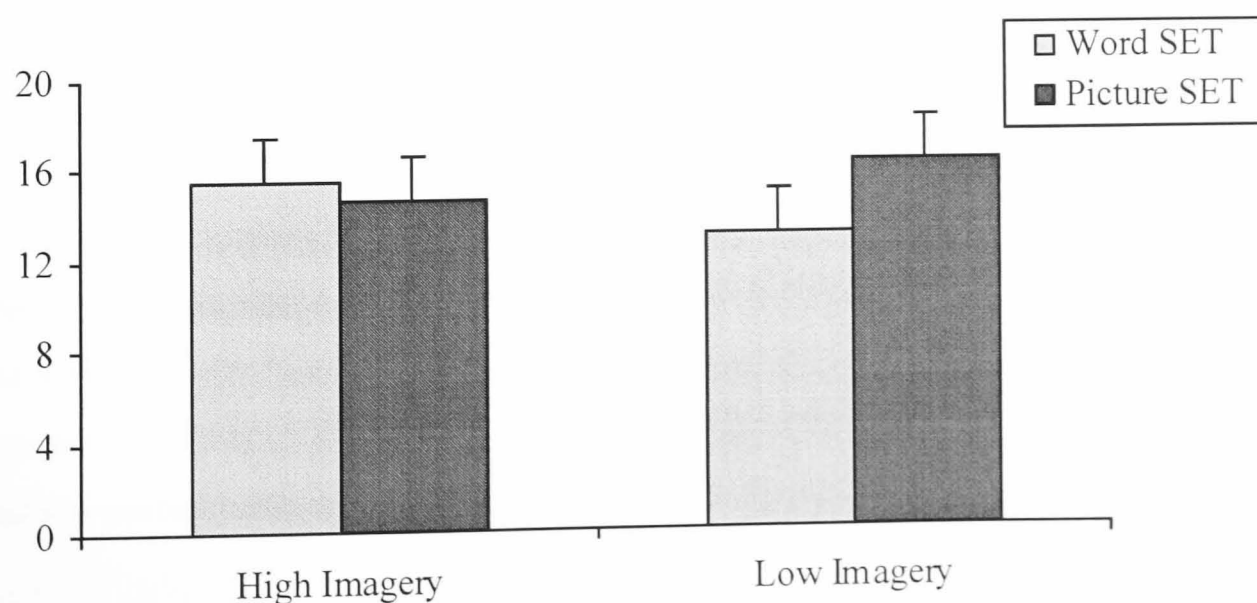
Materials and Procedure. The participants were given the eyes open version of the VVIQ and the VPIQ. These measures were fully defined in Chapter Five. Once they had completed the self-report measures they carried out the two versions of the SET. The first version of the SET consisted of four stimulus images presented in their standard written format. The second version consisted of the standard written stimulus images accompanied with computer-drawn perceptual representations (see Appendix 10.1). As two of the ten stimulus images used in the standard SET are auditory (“The sound of a foghorn” and “The increasing loud and steady sound of a drum”) they were removed from the present study. Instead the participants were given four stimulus images in each presentation with a maximum of five responses to each stimulus image (see Appendix 10.1).

Results

The SET was blind-rated by two judges using the procedure outlined by Barron (1988). As an inter-rater reliability coefficient exceeded 0.8, a combined score was obtained. An analysis of order effects was not significant ($F(1,22)=0.09$, $MSe=45.81$, $p>0.05$). However, an independent groups analysis of variance showed that the split-halves of the SET produced significantly different responses ($F(1,20)=6.63$, $MSe=35.34$, $p<0.05$). As the halves were counterbalanced, they do not detract from the findings. However, they do demonstrate differences in responding to the stimulus images and therefore reduce the overall power of the final analyses.

The mean responses for the high and low imagery groups on the two forms of the SET are presented in Figure 10.3. These suggest that although the two groups performed equivalently on the SET, there appears to be a preference for visually accompanied information in the low imagery group. In order to test the hypothesis that the high and low imagery groups would differ in their performance on the two versions of the SET a mixed ANOVA was carried out. This showed that the high and low imagery groups performed the same on the overall SET ($F(1,22)=0.01$, $MSe=102.89$, $p>0.05$). They also showed that the two versions of the SET yielded similar performance ($F(1,22)=1.73$, $MSe=10.15$, $p>0.05$). However, there was a predicted significant interaction effect between self-reported imagery ability and the type of SET presentation ($F(1,22)=5.13$, $MSe=10.15$, $p<0.05$).

Figure 10.3. Mean Scores for the High and Low Imagery Groups by the Type of SET Task (With Standard Error Bars).



Simple main effects analyses revealed no significant differences between the high and low imagery groups when the perceptually sourced ($F(1,22)=0.33$, $MSe=56.50$, $p>0.05$) and verbally sourced ($F(1,22)=0.62$, $MSe=0.62$, $p>0.05$) conditions were assessed for the two imagery groups. Furthermore, a separate analysis on the high imagery scores for the perceptually and verbally sourced SET presentations was not significant ($F(1,22)=0.45$, $MSe=10.15$, $p>0.05$). However, when the low imagery groups scores were analysed it was found that they performed significantly better on the perceptually sourced version of the SET than on the verbally sourced version of the SET ($F(1,22)=6.42$, $MSe=10.15$, $p<0.05$). Overall these findings suggest that perceptually congruent information assisted performance on the SET for the low imagery group but not for the high imagery group.

Discussion

The findings from the present study showed that Low Imagers performed significantly better on a perceptually sourced version of Barron's SET than on a verbally sourced version. Although the High Imagers performed better on the verbally sourced version of the SET a simple main effect analysis failed to show a significant difference between the two conditions. Overall these findings suggest that the addition of perceptual information aids performance in individuals' who score low in self-reported verbally sourced vividness of visual imagery.

The findings from the present research further support the role of perceptual information in predicting high and low imagery groups abilities on a creativity task. These findings are consistent with the findings from Study Twelve and illustrate the need for further research into perceptual mediation in the role of mental imagery in creativity. They also conform to the consistent research finding that self-reported mental imagery is statistically related to creativity in the standard creativity measures but that this association is statistically inconsequential. In the present study high and low imagery groups were derived from verbally sourced self-report measures. As these measures do not correlate with behavioural measures of spatial mental imagery that are perceptually sourced (Di Vesta *et al.*, 1971; Ernest, 1977) then it would be interesting to assess high and low performance on spatial imagery tasks.

As was noted self-report measures of mental imagery are not normally associated with spatial measures of mental imagery. Furthermore, several researchers have suggested that there is a dissociation between spatial and visual measures of mental imagery (Farah *et al.*, 1988; Kosslyn, 1994). The results from the present study suggest a further distinction that may prove to be of particular benefit in future research. This is that there is a very obvious difference between perceptually sourced protocols and verbally sourced self-report measures. This distinction seems so obvious that it is surprising that mental imagery researchers have failed to investigate it in the context of the visual and spatial imagery dissociation previously noted.

General Discussion

The aim of the present chapter was to pilot new methods for studying the role of mental imagery in creativity. The underlying theme of the two studies was that creative performance needs to be understood in the context of interacting imaginal and perceptual processes. In the first study it was shown that perceptual isolation resulted in improved performance on Barron's Symbolic Equivalence Task in the high imagery group but not the low imagery group. The second study showed that verbally sourced self-reported Low Imagers performed better on a perceptually sourced version of Barron's SET than on a verbally sourced version of the SET. Although more research is required, these studies demonstrate that the role of mental imagery in creativity is mediated by perceptual factors.

Given that the anecdotal reports of the role of mental imagery in creativity strongly suggest that perceptual information mediates performance, it is surprising that the research literature has ignored this factor. The first study simply took the most obvious conclusion from the anecdotal literature, that the use of mental imagery in historical creativity tends to occur in perceptually isolated circumstances, and assessed it in the context of individuals that report vivid and non-vivid imagery. The hypothesis was based upon an assumption derived from Chapter One, namely, that mental imagery is not a necessary condition for creativity but could be used by certain individuals in certain environments. The results from the study supported this hypothesis and showed that previous research may have been correct in its selection of the individuals but had failed to develop appropriate conditions.

The findings from Study Twelve show that perceptual information in the environment is important and concurs with previous research which investigated fantasy proneness and perceptual isolation (Tushup and Zuckerman, 1977). Further research is required to clarify the effect and to investigate optimal perceptual isolation periods. This may show the link between fantasy proneness and imagery vividness in predicting creativity.

Having established that self-reported mental imagery predicts performance differences in circumstances where perceptual information is manipulated the final study in the thesis aimed to show that Low Imagers preferred tasks that have additional perceptual information. The findings from this study showed that the source of the to-be-imaged stimuli is an important predictor of performance in high and low imagery groups. These results have important implications for future research into mental imagery *per se* and the overlooked concept of perceptual and verbal source may help to explain why previous research has failed to find associations between measures of mental imagery. Further research is required.

Conclusion

In this final empirical chapter into the role of mental imagery in creativity a new perspective was developed in which the mediating role of perceptual processes was investigated. In the first experiment it was shown that the high imagery group performed significantly better than the low imagery group on a creativity task when perceptual interference effects were removed. Conversely, the second experiment showed that the low imagery group performed better than the high imagery group on a perceptually sourced version of the SET than on a standard verbally sourced version of the task. Overall the findings suggest that perceptual processes are key mediators of the role of mental imagery abilities in the performance of creativity tasks. Furthermore, the mediation effect interacts with individual imagery abilities.

Chapter XI

Conclusions on the Role of Mental Imagery in Creativity

Introduction

In the first chapter it was noted that mental imagery is neither a necessary nor a sufficient condition for creativity. However, this statement was intended to temper many exaggerated claims about the link between mental imagery and creativity rather than to diminish the importance of mental imagery in creativity. The significance of the use of mental imagery was reinforced through two case studies of historical creativity reported in Chapter One, a reinterpretation of what a mental image is in Chapter Two, and the review of the different kinds of mental imagery carried out in Chapter Three.

These three chapters set the framework for empirical research into the role of mental imagery in creativity. Collectively they illustrate four issues in the imagery-creativity debate. The first of these (demonstrated in the final study) is that *mental imagery should not be presumed in all cases of creativity* and in some circumstances it may even become a false icon in the problem solving process. The second statement accepts that there are many examples of the use of mental imagery in historical creativity but notes that *there is not a single form of imaging that will lead to creative insights*. This was most clearly demonstrated in Chapter Three and receives further support from the empirical research carried out throughout the thesis. The third statement claims that a link with creativity inevitably entails the *rejection of a strong perceptual equivalence hypothesis*. This statement is supported by the empirical research carried out in the penultimate chapter which showed that mental images have exclusive properties that facilitate creativity. The final statement is that *creativity is associated with a diverse range of mental images* which require investigation from a number of perspectives.

While these statements have been considered in the present thesis, previous research into the role of mental imagery is based primarily upon the numerous reports of historical creativity outlined in Chapter Three. The dominant methodologies, designated as “the individual differences approach” and “the image generation approach”, rarely go beyond the documentary support of historically creative individuals. This may explain why the findings from the

empirical research are driven more by statistical significance than by theoretical importance.

Studying the role of mental imagery in creativity is a fascinating experience but the elusive nature of the two variables makes the task very difficult. In the present thesis the role of mental imagery has been studied in a variety of new ways. However, there are many more ways in which imagery and creativity could be investigated. In the following discussion the main empirical findings are assessed and suggestions for further research are made.

The Individual Differences Approach

The aim of first three chapters was to develop a description of mental imagery that enabled the many forms to be categorised and evaluated in the context of their role in creativity. In carrying this out it was found that the main protocol used to empirically investigate mental imagery and creativity was the individual differences approach. The main features of this approach were, firstly, the application of self-report measures of mental imagery and, secondly, the use of divergent thinking measures of creativity. As a sufficient amount of research had been carried out using this protocol, it was decided that a meta-analytic investigation may provide further information about the role of mental imagery in creativity.

In order to carry out the meta-analysis a set of criteria were established on the basis of the broader research into mental imagery and 14 studies were identified which employed the individual differences approach. As many of these studies failed to meet a necessarily conservative set of criteria, a meta-analysis was carried out on six studies with a total sample size of 752 participants. The findings from the main meta-analysis showed that self-reported mental imagery was consistently associated with divergent thinking abilities. However, the actual effect size only met the criterion for marginal acceptability (Cohen, 1992, McKelvie, 1995).

As the six studies tended to use two specific characteristics of mental imagery and two forms of divergent thinking, meta-analytic procedures were carried out for each of these in order to identify stronger predictors of the role of

mental imagery in creativity. The findings showed that self-reported control of mental imagery was a better predictor of performance on the divergent thinking tasks than the vividness of mental imagery. It was also found that figural divergent thinking tasks had a stronger association with the self-report measures of mental imagery than the verbal divergent thinking tasks. However, in both cases the differences in effect size were not statistically large enough to warrant a theoretical explanation.

Although meta-analytic procedures provide useful gross estimates of the relationship between variables, they are still prone to masking inconsistencies in data sets which are detectable through observation. Non-statistical observation of the data sets showed that there were several inconsistencies in these studies. The first of these was the finding that some studies emphasised the role of vividness over the control of imagery (Parrott and Strongman, 1985) and others the role of control over the vividness of imagery (Forisha, 1981). Other inconsistencies were found in the role of sex differences in mental imagery (Forisha, 1981; Campos and Perez, 1987) and in the emphasis upon co-dependent variable (Bowers, 1978; Parrott and Strongman, 1985; Shaw and DeMers, 1986). Furthermore, there were large differences in the ways in which the mental imagery and divergent thinking measures were scored.

In summarising the findings from this study, it was concluded that the most frequently employed method of investigating the role of mental imagery in creativity has produced a consistent overall association between mental imagery and divergent thinking abilities. However, the association is small (Cohen, 1992) and when the studies are individually examined several contradictory findings emerged. Consequently, it was concluded that further research needs to be conducted in which the standard measures are evaluated for construct validity and internal reliability prior to carrying out correlational research.

Having decided that further research into the construct nature of the self-report measures of mental imagery was required, two factor analytic studies were carried out on the most frequently used measures. The investigation into the eyes-open version of Marks' VVIQ (1972, 1973) showed that the scale had reasonably good parametric properties but produced an expected response leniency effect

(McKelvie, 1995). A PCA analysis with oblique rotation suggested a one or three factor solution. As the three factors showed good internal reliability and the composite scores were shown to produce significantly different responses the three factor solution was adopted for further research into the individual differences approach.

The A.Richardson (1969) version of the TVIC had been employed as a continuous variable by three of the six studies selected for the meta-analysis in Chapter Four. As the best known version of the TVIC this measure was distributed to 167 participants and the data were subjected to the same procedures as those used to assess the eyes-open version of the VVIQ. However, the TVIC showed an extreme response leniency and it became apparent that this measure should not be employed as a continuous variable. As the data from this study did not differ from previous factor analytic studies, which had ignored the problems of skew and kurtosis (Ashton and White, 1974; Kihlstrom *et al.*, 1991), it was necessary to consider alternative ways of using the TVIC. Eventually it was concluded that the only way in which the TVIC could produce statistically reliable information is when it is treated as a trichotomous variable (Khatena, 1975).

Having shown that the eyes-open version of the VVIQ could be treated as a three factor instrument and that A.Richardson's version of the TVIC should be employed as a trichotomous variable, the two self-report measures were employed in a study of self-reported mental imagery and divergent thinking. Two shortened forms of Torrance's test of creative thinking were employed and measures of fluency, flexibility, and originality were derived for each test. Correlational analyses for the vividness factors concurred with the previous research in that they showed a small but consistent association with the sub-measures of divergent thinking. However, the control measure produced no effect and the only observable trend was the opposite to that found in the previous research. This finding suggested that when the control measure is treated as a trichotomous variable it does not predict performance on the divergent thinking tasks. Overall the effect size from this study was lower than that found in the meta-analysis. The reasons for this were attributed to the necessary changes made to the control

measure and it was concluded that further research was required to develop a better measure of the control of mental imagery.

As the self-report measures of the vividness and control of mental imagery showed inconsequential criterion validity (McKelvie, 1995), a new measure of the vividness of mental imagery was developed which was specifically linked to creativity. This measure, referred to as the Vividness of Poetry Imagery Questionnaire (VPIQ), consisted of four blocks of figurative poetry. The aim of the task was to read the passages of poetry and then rate the vividness of specific extracts of the prose. A study of the VPIQ showed that it had reasonably good parametric properties but exhibited a small response leniency effect. It also showed that the VPIQ consisted of four factors but one these did not load significantly on any of the items. The other three factors showed sufficient internal reliability and their composite scores were significantly different.

The final study in this series assessed the association between the three factors derived from the VPIQ and the sub-measures of divergent thinking derived from shortened and standard forms of the Torrance tests. As the standard form of divergent thinking did not produce a stronger effect size, the two forms were analysed in a multiple partial correlation design. The findings from this study once again showed a consistent association between self-reported vividness of mental imagery and divergent thinking performance. However, the use of a self-report measure that was linked to creativity failed to elicit a stronger association between the imagery and divergent thinking variables.

The results from the two criterion studies carried out in Chapter Five were combined with the studies reported in Chapter Four (and a further study carried out after the first meta-analysis; Gonzalez *et al.*, 1997) and a final meta-analytic procedure was conducted. This study was derived from 9 studies in which 1,494 participants were tested. Overall the addition of the studies carried out in Chapter Five and the inclusion of the Gonzalez *et al.* (1997) study resulted in a reduction in the overall effect size from a Fisher's r of 0.20 to a Fisher's r of 0.15. Although this reduction is very small it is important because the effect size no longer meets a minimally acceptable criterion validity suggested by McKelvie (1995) in his meta-analytic review of the VVIQ. Thus, according to McKelvie's criterion the

association between self-reported mental imagery and divergent thinking ability does not appear to have statistical or theoretical importance.

As the studies carried out after the initial meta-analysis employed measures of vividness and control, separate analyses were carried out for each of the characteristics of mental imagery. Although the two studies carried out in Chapter Five used different measures of mental imagery, they both measured the vividness characteristic and were therefore included in the first analysis. The final Fisher's r coefficient was 0.14 which was very similar to the findings for the two studies carried out in Chapter Five.

The re-examination of the control measure of mental imagery represented a dilemma. Although an overall measure of effect was desirable, all of the studies that employed a measure of control treated it as a continuous variable. As the factor analytic study showed that this procedure produced statistically unreliable results, it was evident that generalisations from these studies could be spurious. Nevertheless, an analysis was carried and the findings showed that the overall effect size was reduced from a marginally acceptable Fisher's r coefficient of 0.17 to an inconsequential Fisher's r coefficient of 0.12.

The same procedure was also carried out on the two forms of divergent thinking. The results from the verbal divergent thinking tasks showed a reduction in the Fisher's r coefficient from a marginally acceptable 0.19 to an inconsequential coefficient of 0.13. The figural divergent thinking tasks also showed a reduction in the overall Fisher's r coefficient from 0.23 to 0.19. However, the association between self-reported mental imagery and figural divergent thinking performance remained within a marginally acceptable criterion validity range.

In assessing the results from the studies carried out using the standard individual differences approach, it was concluded that new ways of assessing the role of imagery abilities in creativity needed to be developed. Generally, the research carried out into self-reported mental imagery and divergent thinking has failed to go beyond the basic empirical finding that there is a consistent association between the two variables. Furthermore, this association is small and with the exception of studies of mental imagery and figural divergent thinking is

statistically inconsequential. One problem with the protocols employed in this research is that they have failed to assess the full scope of mental imagery abilities. For example, there is a distinct lack of studies which have employed behavioural measures of mental imagery. Finally, the divergent thinking tasks employed in these studies may not require imagery processing at all, so it would be better to choose measures of creativity where there are stronger theoretical grounds for predicting the use of mental imagery. If the individual differences approach is going to provide useful information about the role of mental imagery in creativity, then these problems need to be addressed.

The Image Generation Approach

As the individual differences approach generally failed to show a statistically important role for mental imagery in creativity, new ways of assessing the role of mental imagery abilities in creativity needed to be developed. In Chapters Seven, Eight, and Nine the second protocol used to investigate the role of mental imagery in creativity was employed in the context of behavioural measures of mental imagery. This was carried out through the development of the pencil and paper version of the creative visualisation task.

The image generation approach to the study of the role of mental imagery in creativity was developed by Finke and Slayton (1988). The aim of this approach is to show that under specific conditions mental images are used to produce creative responses. The main difference between this approach and the individual differences approach is that mental imagery abilities are not seen as important in determining their use in creativity. Consequently, the protocols employed in this research are not designed to elicit information about individual differences. Thus, the aim of the first study undertaken in this section was to develop a measure of creative visualisation that could be used to differentiate people's abilities on the task.

A pilot study of a pencil and paper version of the creative visualisation task showed that it had sufficient parametric properties to be employed as a dependent variable measure of a particular form of creativity. Consequently three studies were carried out to assess the role of mental imagery abilities in predicting

performance on the task. The first two studies employed two well known behavioural measures of spatial and visual mental imagery (the mental rotation task and the mental clocks comparison task) and the third assessed self-reported vividness of mental imagery in the context of high and low Symbolic Equivalence Task (SET) performance.

It had been noted in the research using the individual differences approach that the standard protocol used to assess the role of mental imagery abilities in performance on creativity tasks employed self-report measures of mental imagery. As there are a large number of protocols which derive behavioural measures of mental imagery performance, it was hypothesised that these tasks may provide further information about the role of individual differences in mental imagery in creativity. The first study into the role of mental imagery abilities in predicting performance on the pencil and paper version of the creative visualisation task used latency and accuracy scores from a version of Shepard's (Shepard and Metzler, 1971; Cooper and Shepard, 1973) mental rotation task. Results from this study suggested that high and low abilities on this particular version of the mental rotation task did not predict performance on any of the measures of creative visualisation.

As the mental rotation task did not predict performance on the pencil and paper version of the creative visualisation task, a further measure of mental imagery abilities was employed in a more complex and thorough design. The mental imagery task selected as a behavioural measure of visual mental imagery ability was a version of Paivio's (1978a) mental clocks comparison task. This task was selected because it is widely referenced in the mental imagery research literature (Kosslyn, 1994; Paivio, 1989; J.T.E.Richardson, 1999), it is possible to develop an equivalent non-imagery version (Moyer and Bayer, 1976), and because it is hypothesised to be a measure of visual (as opposed to spatial) imagery ability (Farah *et al.*, 1988).

A two-way independent groups experiment in which high and low imagery and arithmetic comparison abilities were assessed failed to show that high imagery comparison abilities predicted performance on the pencil and paper version of the creative visualisation task. Furthermore, analyses suggested that the

arithmetic condition was a better predictor of performance on the creative visualisation task than the imagery condition. These results were found despite the fact that the participants reported the use of mental imagery on the imagery comparison task and the creative visualisation task but not on the arithmetic comparison task.

The results from the studies carried out in Chapter Eight were disappointing. Combined they showed that behavioural measures of mental imagery ability did not predict performance on the pencil and paper version of the creative visualisation. One positive finding from the research reported in this chapter was that the pencil and paper version of the creative visualisation task yielded good parametric findings. Furthermore an impetus for continued research was the finding that the participants reported the use of mental imagery in the task. As abilities on the two behavioural measure of mental imagery failed to predict performance on the creative visualisation task, the final study in this series of investigation assessed self-reported mental imagery abilities. However, the research from the studies undertaken throughout the thesis suggested that research should go beyond a straightforward linear association between of mental imagery and creativity.

A closer examination of the research carried out into the processes involved in the creative visualisation task suggested that mental imagery abilities may be dependent upon creative interpretation processes (Finke, 1990). In order to assess this hypothesis the final study into the role of mental imagery abilities in the pencil and paper version of the creative visualisation task, a measure of high and low creative interpretation abilities was derived from Barron's (1988) symbolic equivalence test. A two-way independent groups design showed that scores on the SET consistently predicted performance on the creative visualisation task. Although the vividness groups were not significantly different there was a significant interaction between self-reported mental imagery and high and low performance on the SET. Further analyses of the interaction effect revealed that self-reported High Imagers who also performed high in SET performance performed significantly better on the creative visualisation task than the other groups.

The studies carried out using the image generation approach represent a new method of investigating the role of imagery differences in performance of creativity tasks. The pencil and paper version of the creative visualisation task has been shown to produce creative responses and mental imagery has been strongly implicated in the task. Although it has been difficult to establish which particular forms of mental imagery play a role in this task, it was eventually found that the self-reported vividness of mental imagery played an important secondary role in predicting performance on the task.

Perceptual Mediation in the Role of Mental Imagery and Creativity

The research carried out in Chapters Four to Nine represents a continuation of previous empirical work into the role of mental imagery and creativity. As before the main focus of the research was on waking-state mental images that have a ‘looking-at’ status. Although these studies provide valuable information about the role of mental imagery in creativity, the anecdotal and theoretical reviews carried out in the first three chapters show that there are many ways in which mental images can be used to facilitate the creative process. The aim of the penultimate chapter was to draw upon the anecdotal reports of the use of mental imagery in historical creativity in order to develop new protocols for studying the two variables.

A major premise derived from the first three chapters was that the use of mental imagery in creativity is dependent upon the amount of perceptually relevant and irrelevant information in the environment. This was highlighted in Chapter Three where it was shown that the majority of anecdotal reports of historical creativity took place in circumstances where internal processing demands dominated thinking. As these anecdotal reports suggest that mental imagery in creativity is mediated by perceptual information, the final studies investigated two aspects of mediation. The first study in Chapter Ten assessed the effects of perceptual isolation in performance on Barron’s SET. The final study looked at perceptually sourced and verbally sourced information in predicting performance on Barron’s SET. Both of these studies demonstrated that the association between individual differences in self-reported mental imagery and

performance on a creativity task was mediated by the presence or absence of perceptual information.

An investigation into the effects of limiting perceptually incongruent information in environment was carried out in the twelfth study. This showed that those with high self-reported mental imagery performed significantly better than those with low self-reported mental imagery on the SET in a perceptually isolated environment but not in a perceptually focused environment. These results may help to explain why mental imagery abilities do not strongly predict performance in ordinary test-room formats. They also suggest that environments which limit the amount of perceptually incongruent information are conducive for the emergence and use of mental imagery in creativity. Further research should investigate optimal isolation periods and the role of mode of presentation.

The final study considered the role of perceptual mediation through a study of perceptually sourced and verbally sourced versions of the SET. Many studies of mental imagery have shown that behavioural and self-report measures of mental imagery are not associated (McKelvie, 1995). Explanations for this dissociation have focused upon the spatial characteristics of the behavioural measures and artifactual accounts of self-report measures of mental imagery (Di Vesta *et al.*, 1971; Harshman and Paivio, 1987; Hiscock, 1978). However, a key difference between these measures of mental imagery seems to have been largely over-looked in the cognitive literature. This is that self-report measures of mental imagery use verbally sourced material and behavioural measures use perceptually sourced material. In the final study information source was investigated through a study of high and low verbally sourced mental imagery abilities.

In Study Thirteen a quasi-experimental design showed that those with high self-reported mental imagery on two vividness measures performed better on a verbally sourced version of the SET than on a perceptually sourced version of the SET. These findings tentatively open up a new method of investigating mental imagery and cognitive abilities and suggest that imagery abilities may be better understood in the context of the source of the information. Combined with the previous study the results from this research also suggest that the role of mental imagery in creativity is influenced by perceptual information and that further

research is required to demonstrate the full breadth of this mediation. This information is available in the anecdotal literature but had previously been neglected by imagery-creativity researchers.

Further Research

There remains a considerable amount of research into the role of mental imagery in creativity. Even though the two best known protocols were investigated and two further studies assessed the mediation of perceptual information, it seems that only the tip of an iceberg has been revealed. This is especially true of the image generation approach and the perceptual mediation model where more verification and elaboration on the effects is required. Each of the three areas is reviewed separately in the following section and new ways of investigating the role of mental imagery in creativity are considered.

The research using the individual differences approach showed that the association between mental imagery and creativity was consistent but small. The overall findings suggest that this method of investigating the role of mental imagery in creativity is not productive and it is surprising that it should represent the majority of the empirical research. While it may be argued that the addition of mediating variables could reveal a stronger association between mental imagery and creativity, in reality these variables seem to obscure the relationship further. What is clearly required is the development of a new measure of the control of mental imagery that covers a broad range of situations in which the control of mental imagery is to be attempted. Given the findings from the penultimate chapter, a fresh approach may be required in which participants are presented with perceptually sourced and verbally sourced versions of the task.

A further requirement for future research is the use of alternative measures of creativity. The meta-analysis carried out in Chapter Six suggested that the measures of figural and verbal divergent thinking were not strongly associated with self-reported mental imagery. The reason for this may be related to the cognitive processes required to perform the task. For example, it has been known for a considerable amount of time that the scores of originality and flexibility are largely explained through fluency (Hocevar, 1979). Given that research into

mental imagery has shown that processing is slow (Denis, 1982) and that the reports of historically creative individuals emphasise free floating thought (Ghiselin, 1952) then it may be better to employ measures that place less emphasis upon speed of processing. Such measures definitely include the pencil and paper version of Finke and Slayton's (1988) creative visualisation task and Barron's (1988) Symbolic Equivalence Test.

The studies carried out into the creative visualisation task and the perceptual mediation model were a response to the problems emphasised in the previous paragraph. The research carried out in Chapters Seven, Eight, and Nine showed that it is possible to employ a pencil and paper version of the creative visualisation task but also failed to show a direct link between imagery abilities and performance on the task. The statement made at the very beginning of the thesis, that mental imagery is neither a necessary nor a sufficient condition for creativity, is clearly supported by these findings. However, the importance of mental imagery was established in the study carried out in Chapter Nine and using this type of protocol in future research is likely to reveal interesting information about the use of imagery in creativity. For example, the failure to show a role for spatial imagery abilities in Chapter Eight may be redressed by an examination of performance in the context of Barron's SET.

The most divergent movement away from the standard individual differences approach was the investigation of perceptual mediation in the role of mental imagery in creativity. Ironically, this area appears to offer the richest vein of information and the closest association to the anecdotal reports of historical creativity which formed the basis for the individual differences research. The initial finding that perceptually isolated environments facilitate High Imagers but not Low Imagers is predicted from the anecdotal literature. This study requires further verification and future research should focus upon the obvious contradiction between cognitive deficits in long-term sensory deprivation (Suedfeld, 1969) and enhancements in short-term studies.

The final study into the role of mental imagery in creativity showed that low verbally sourced mental imagers performed better on a perceptually sourced version of Barron's SET and high verbally sourced imagers performed better on a

verbally sourced version of the SET. Again further research is necessary in order to verify this finding. With the possibility of revealing a new way in which mental imagery abilities can be understood the general application of this protocol may provide the clarity that has been missing in mental imagery research. That a study of mental imagery and creativity requires this clarity puts a paradoxical twist on Shepard's (1978) claim that creativity is a *raison d'être* for studying mental imagery.

The aim of the thesis was to examine the link between mental imagery and creativity. Following a review of the theoretical, anecdotal and empirical evidence the individual differences approach was employed in three areas of inferred relevance. Although the research has covered the two main empirical approaches and analyses of perceptual mediation were undertaken, there remain large areas of interest that have not been investigated. Some of these areas were briefly noted in the review carried out in Chapter Three (synaesthesia, memory images) and others have emerged from the research undertaken (the role of stimulus attributes). In summary the scope for research may be difficult, but there are many more avenues along which mental imagery and creativity can be explored.

Conclusion

The studies presented in this thesis have meandered through what is a challenging but rewarding area to research. In an attempt to close the gap between the anecdotal support for the role of mental imagery in historical creativity and the empirical research, several new protocols have been developed. The most important conclusions to be drawn from the research are threefold. Firstly, it has been demonstrated that the standard individual differences approach in which a self-reported measure of mental imagery is correlated with measures of divergent thinking shows a statistically inconsequential relationship between mental imagery and creativity. Secondly, it has been shown that an alternative protocol, the image generation approach, can be used as a measure of individual differences in creative visualisation and that self-reported mental imagery plays an important secondary role in predicting performance on the task. Finally, it has been found

that the role of mental imagery in creativity needs to be understood in the context of the perceptual information in the immediately surrounding environment.

It is hoped that the material presented in the thesis will eventually lead to a better understanding of how mental imagery predicts performance on creativity tasks. The ‘multifaceted’ nature of the role of mental imagery in creativity has been noted by many researchers but few have tried to develop new methods of inquiry. More research using new methods is required if a full understanding of the two variables is ever to be achieved. Given the breadth of mental imagery and creativity this will demand a considerable amount of research.

(WORD COUNT 74,689)

Bibliography

- Aghajanian, G.K. (1994). Serotonin and the action of LSD in the brain. *Psychiatric Annals*, **24**, 137-141.
- Ahsen, A. (1982). Principles of imagery in art and literature. *Journal of Mental Imagery*, **6**, 213-250.
- Ahsen, A. (1985). Unvividness paradox. *Journal of Mental Imagery*, **9**, 1-18.
- Ahsen, A. (1987). Epilogue to the unvividness paradox. *Journal of Mental Imagery*, **11**, 13-60.
- Ahsen, A. (1988). Hypnagogic and hypnopompic imagery transformations. *Journal of Mental Imagery*, **12**, 1-50.
- Ahsen, A. (1993). Imagery treatment of alcoholism and drug abuse: a new methodology for treatment and research. *Journal of Mental Imagery*, **17**, 1-61.
- Ahsen, A. (1997). Visual imagery and performance during multisensory experience, synaesthesia and phosphenes. *Journal of Mental Imagery*, **21**, 1-41.
- Alpert, M. (1986). Language processes and hallucination phenomena. *Behavioral and Brain Sciences*, **8**, 518-519.
- Alvarez, A.(1994). Creativity and the dynamics of dreaming. *The Times Literary Supplement*, **4786**, 12-21.
- Amabile, T.M. (1982). Social psychology of creativity: a consensual assessment technique. *Journal of Personality and Social Psychology*, **43**, 997-1013.
- Anderson, J.R. (1978). Arguments concerning representations for mental imagery. *Psychological Review*, **85**, 249-277.
- Anderson, R.E. and Helstrup, T. (1993). Visual discovery in mind and on paper. *Memory and Cognition*, **21**, p.283-293.
- Antonietti, A., Bologna, D., and Lupi, G. (1997). Creative synthesis of visual images is not associated with individual differences. *Perceptual and Motor Skills*, **85**, 881-882
- Antonietti, A. and Colombo, B. (1997) The spontaneous occurrence of mental visualization in thinking. *Imagination-Cognition-and-Personality*, **16**, 415-428.
- Antonietti, A. and Giorgitti, M. (1996). A study of some psychometric properties of the Verbalizer-Visualizer Questionnaire. *Journal of Mental Imagery*, **20**, 59-68.

- Aserinski, E. & Kleitman, N. (1953). Regularly occurring periods of eye motility and concurrent phenomena during sleep. *Science*, **118**, 273-274.
- Ashton, A. and White, K. (1974). Factor analysis of the Gordon Test of Visual Imagery Control. *Perceptual and Motor Skills*, **38**, 945-946.
- Ashton, R. and White, K.D. (1980). Sex differences in imagery vividness: an artifact of the test. *British Journal of Psychology*, **71**, 35-38.
- Atkinson, R.C. (1975). Mnemotechnics in second-language learning. *American Psychologist*, **30**, 821-828.
- Atkinson, R.C. and Raugh, M.R. (1975). An application of the mnemonic keyword method to the acquisition of a Russian vocabulary. *Journal of Experimental Psychology: Human Learning and Memory*, **104**, 126-133.
- Austin, M.D. (1971). Dream recall and the bias of intellectual ability. *Nature*, **231**, 59.
- Baars, B.J. (1988). *A Cognitive Theory of Consciousness*. Cambridge: Cambridge University Press.
- Baddeley, A.D. (1997). *Human Memory: Theory and Practice*. Hove: Psychology Press.
- Baddeley, A.D. and Lieberman, K. (1980). Spatial working memory. In R.S.Nickerson (Ed.), *Attention and Performance VIII*. Hillsdale: Erlbaum.
- Ball, O.E. and Torrance, E.P. (1978). Culture and tendencies to draw objects in internal visual perspective. *Perceptual and Motor Skills*, **47**, 1071-1075.
- Banks, W.P., Fujii, M., and Kayra-Stuart, F. (1976). Semantic congruity effects in comparative judgements of magnitude of digits. *Journal of Experimental Psychology*, **2**, 435-447.
- Barron, F. (1955). The disposition toward originality. *Journal of Abnormal and Social Psychology*, **51**, 478-485.
- Barron, F. (1969). *Creative Person and Creative Process*. New York: Holt, Rinehart, and Winston Inc.
- Barron, F. (1988). Putting creativity to work. In R.J.Sternberg (Ed.), *The Nature of Creativity: Contemporary Psychological Perspectives*. Cambridge: Cambridge University Press. Pp. 76-98.
- Barron, F. (1990). *Creativity and Psychological Health: Origins of Personal Vitality and Creative Freedom*. Buffalo, NY: Creative Education Foundation.

- Barron, F. and Harrington, D.M. (1981). Creativity, intelligence, and personality. *Annual Review of Psychology*, **32**, 439-476.
- Bartlett, F.C. (1932). *Remembering: A study in experimental and social psychology*. London: Cambridge University Press.
- Bartlett, F.C. (1958). *Thinking: An Experimental and Social Study*. London: Allen & Unwin.
- Benjafield, J. (1987). An historical, social analysis of imagery and concreteness. *British Journal of Social Psychology*, **26**, 155-164.
- Bentall, R.P. (1990). Concluding remarks. Schizophrenia - a suitable case for treatment? In R.P.Bentall (Ed.), *Restructuring Schizophrenia*. London: Routledge.
- Blackmore, S. (1991). Lucid Dreaming: Awake in your sleep. *Skeptical Inquirer*, **15**, 362-370.
- Block, N. (1983). Mental pictures and cognitive science. *Philosophical Review*, **93**, 499-542.
- Boden, M. (1990). *The Creative Mind: Myths and Mechanisms*. London: An Abacus Book.
- Boden, M.A. (1994). *Dimensions of Creativity*. London: MIT Press.
- Bowers, P. (1978). Hypnotizability, creativity and the role of effortless experiencing. *The International Journal of Clinical and Experimental Hypnosis*, **26**, 184-202.
- Bowers, K.S., Regehr, G., Balthazard, C., and Parker, K. (1990). Intuition in the context of discovery. *Cognitive Psychology*, **22**, 72-110.
- Broerse, J. and Crassini, B. (1980). The influence of imagery ability on color aftereffects produced by physically present and imagined induction stimuli. *Perception and Psychophysics*, **28**, 560-568.
- Broerse, J. and Crassini, B. (1984). Investigations of perception and imagery using CAEs: The role of experimental design and psychophysical method. *Perception and Psychophysics*, **35**, p.155-164.
- Brosigole, L., Chan, T.C., Brandt-Tiven, T.E., Miller, E.K., and Sanders, D.M. (1997). Alternating between two imaginary stimuli may produce phi. *Journal of Mental Imagery*, **3&4**, 55-72.
- Brooks, L.R. (1967). The suppression of visualization by reading. *Quarterly Journal of Experimental Psychology*, **22**, 91-96.

- Brown, N.R. and Siegler, R.S. (1991). Subjective organization of U.S. presidents. *American Journal of Psychology*, **104**, 1-33.
- Bull, M. (1995). Liberty Boy-genius, Biography Features. *The Times Literary Supplement*, **4829**, 3-10.
- Butcher, H.J. (1968). Human Intelligence. Its nature and assessment. London: Methuen and Co.
- Campos, A. and Gonzalez, M.A. (1993). Self-perceived creativity and vividness of mental imagery. *Perceptual and Motor Skills*, **77**, 1291-1296.
- Campos, A. and Perez, M.A. (1994). Influence of creativity on vividness of mental imagery. *Perceptual and Motor Skills*, **78**, 1067-1071.
- Campos, A., and Perez, M.J. (1989). High and low Imagers and their scores on creativity. *Perceptual and Motor Skills*, **68**, 403-406.
- Cauthorne, C. (1985). Creativity and eidetic psychotherapy. *Journal of Mental Imagery*, **9**, 9-16.
- Cerfe-Beare, A. (1993). Visual imagery and the horizontal-vertical illusion pattern. *Journal of Mental Imagery*, **17**, 95-110.
- Chamber, D. and Reisberg, D. (1985). Can mental images be ambiguous? *Journal of Experimental Psychology: Human Perception and Performance*, **11**, 317-328.
- Chambers, D. and Reisberg, D. (1992). What an image depicts depends on what an image means. *Cognitive Psychology*, **24**, p.145-174.
- Chandiramani, K., and Varma, V.K. (1987). Imagery in schizophrenic patients compared with normal controls. *British Journal of Medical Psychology*, **60**, 355-341.
- Churchland, P.S. (1989). *Neurophilosophy. Toward a Unified Science of the Mind-Brain*. London: The MIT Press.
- Coe, W.C. (1989). Posthypnotic amnesia: theory and research. In N.P.Spanos and J.F.Chaves (Eds.). *Hypnosis: The Cognitive-Behavioral Perspective*. New York: Prometheus.
- Cohen, J. (1992). A power primer. *Psychological Bulletin*, **112**, 155-159.
- Cohen, D. and MacKeith, S.A. (1991). *The Development of Imagination. The private worlds of childhood*. London: Routledge.
- Cohen, I.B. (1987). *The Birth of a New Physics*. Harmondsworth, Middlesex: Penguin Books.

- Cohen, L. & Deheane, S. (1991). Neglect dyslexia for numbers? A case report. *Cognitive Neuropsychology*, **8**, 39-58.
- Coleridge, S.T. (1985). Prefatory note to Kubla Khan. In B.Ghiselin (Ed.), *The Creative Process*. Berkeley: University of California Press. Pp. 83-84.
- Combs, A. and Khan, D. and Krippner, S. (1998). The dreaming brain as a self-organizing system. Presented at, *Toward a Science of Consciousness 1998 "Tuscon III"*. Tuscon, Arizona, April 27th to May 2nd.
- Cooper, L.A. (1990). Mental representation of three-dimensional objects in visual problem solving and recognition. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, **16**, 1097-1106.
- Cooper, L.A. and Shepard, R.N. (1973). Chronometric studies of the rotation of mental images. In W.G.Chase (Ed.), *Visual Information Processing*. New York: Academic Press. Pp. 76-176.
- Cooper, L.A. and Shepard, R.N. (1975). Mental transformations in the identification of left and right hands. *Journal of Experimental Psychology: Human Perception and Performance*, **1**, 48-56.
- Cox, R.H. (1994). *Sports Psychology: Concepts and Applications (third edition)*. Iowa: Brown and Benchmark.
- Craver-Lemley, C. and Reeves, A. (1987). Visual imagery selectively reduces vernier acuity. *Perception*, **16**, 533-614.
- Craver-Lemley, C. and Reeves, A. (1992). How visual imagery interferes with vision. *Psychological Review*, **99**, 633-649.
- Crawford, H.J. (1982). Hypnotizability, daydreaming styles, imagery vividness, and absorption: a multidimensional study. *Journal of Personality and Social Psychology*, **42**, 915-926.
- Crick, F. and Mitchison, G. (1983). The function of REM sleep. *Nature*, **304**, 111-4.
- Daniels-McGhee, S. and Davies, G.A. (1994). The imagery-creativity connection. *The Journal of Creative Behavior*, **28**, 151-176.
- Davidson, J.M. (1976). The physiology of meditation and mystical states of consciousness. *Perspectives in Biology and Medicine*, **19**, 345-80.
- Davison, G.C. & Neale, J.M. (1990). *Abnormal Psychology, fifth edition*. New York: John Wiley & Sons.

- De Beni, R., Moè, A., and Cornoldi, C. (1997). Learning from texts or lectures: loci can interfere with reading but not listening. *European Journal of Cognitive Psychology*, **9**, 401-415.
- Deheane, S. (1992). Varieties of numerical abilities. *Cognition*, **44**, 1-42.
- Delmonte (1990) Meditation: Contemporary theoretical approaches. In M.A. West (eds.), *The Psychology of Meditation*. Oxford: Clarendon Press. Pp. 39-53.
- Denis, M. (1982). Imaging while reading text: A study of individual differences. *Memory and Cognition*, **10**, 540-545.
- Denis, M. and Carfantan, M. (1985). People's knowledge about images. *Cognition*, **20**, 49-60.
- Denis, M. and Carfantan, M. (1986). What people know about visual images: A metacognitive approach to imagery. In D.G. Russell, D.F. Marks, J.T.E. Richardson (Eds.), *Imagery 2*, Dunedin: Human Performance Associates. Pp. 27-32.
- Denis, M. and Cocude, M. (1989). Scanning visual images generated from verbal descriptions. *European Journal of Cognitive Psychology*, **1**, 293-307.
- Denis, M. and Kosslyn, S.M. (1999). Scanning visual mental images: A window on the mind. *Cahiers de Psychologie Cognitive*, **18**, 1-57.
- Di Vesta, F.J., Ingersoll, G., and Sunshine, P. (1971). A factor analysis of imagery tests. *Journal of Verbal Learning and Verbal Behavior*, **10**, 471-479.
- Domino, G. (1989). Synesthesia and creativity in fine arts students: an empirical look. *Creativity Research Journal*, **2**, 17-29.
- Durndell, A.J. and Wetherick, N.E. (1977). The relation of reported imagery to cognitive performance. *British Journal of Psychology*, **67**, 501-506.
- Einstein, A. (1905/1923). On the electrodynamics of moving bodies. In A. Sommerfield, W. Perrett and G.B. Jeffery (Trans.), *The Principle of Relativity. A collection of original memoirs on the special and general theory of relativity*. London: Dover Publications. Translated from, Zur Elektrodynamik bewegter Körper. *Annalen der Physik*, **17**, 1905.
- Einstein A. (1920). *Relativity. The Special and the General theory*. London: Methuen.
- Ellis, R.D. (1995). *Questioning Consciousness. The interplay of imagery, cognition and emotion in the human brain*. Philadelphia: John Benjamins Publishing Co.
- Empson, J. (1994). *Sleep and Dreaming (second edition)*. London: Harvester Wheatsheaf.
- Epstein, L.C. (1965). *Relativity Visualized*. San Francisco: Insight Press.

- Ernest, C.H. (1977). Imagery ability and cognition: a critical review. *Journal of Mental Imagery*, **2**, 275-290.
- Eysenck, H.J. (1994). The measurement of creativity. In M.A.Boden (Ed.), *Dimensions of Creativity*. London: MIT Press. Pp.199-242.
- Eysenck, H.J. (1995). *Genius. The natural history of creativity*. Cambridge: Cambridge University Press.
- Eysenck, M.W. and Keane, M.T. (1997). *Cognitive Psychology: A Student Handbook (fourth edition)*. Hove: Lawrence Earlbaum.
- Fancher, R.E. (1979). *Pioneers of Psychology. Studies of the Great Figures who Paved the way for the Contemporary Science of Behavior*. New York: W.W.Norton & Company.
- Farah, M.J. (1985). Psychophysical evidence for a shared representational medium for mental images and percepts. *Journal of Experimental Psychology: General*, **114**, 91-103.
- Farah, M. (1988). Is visual imagery really visual? Overlooked evidence from neuropsychology. *Psychological Review*, **95**, 307-317.
- Farah, M.J., Hammond, K.M., Levine, D.N., and Calvinio, R. (1988). Visual and spatial mental imagery: Dissociable systems of representation. *Cognitive Psychology*, **20**, 439-462.
- Feldhusen, J.F. and Goh, B.G. (1995). Assessing and accessing creativity: an integrative review of theory, research, and development. *Creativity Research Journal*, **8**, 231-247.
- Feldman, D.H. (1988). Creativity: dreams, insights, and transformations. In R.J.Sternberg (Ed.), *The Nature of Creativity: Contemporary Psychological Perspectives*. Cambridge: Cambridge University Press. Pp. 271-297.
- Fenwick, P. (1990). Meditation and the EEG. In M.A.West (Ed.), *The Psychology of Meditation*. Oxford: Clarendon Press. Pp. 104-117.
- Finke, R.A. (1980). Levels of equivalence in imagery and perception. *Cognitive Psychology*, **11**, 235-264.
- Finke, R.A. (1985). Theories relating mental imagery to perception. *Psychological Bulletin*, **98**, 236-259.
- Finke, R.A. (1989). *Principles of Mental Imagery*. Cambridge, MA.: MIT Press.
- Finke, R.A. (1990). *Creative Imagery: Discoveries and Inventions in Visualization*. Hillsdale: Lawrence Erlbaum Associates.

- Finke, R.A. (1996). Imagery, creativity, and emergent structure. *Consciousness and Cognition*, **5**, 381-393.
- Finke, R.A. and Kosslyn, S.M. (1980). Mental imagery acuity in the peripheral visual field. *Journal of Experimental Psychology: Human Perception and Performance*, **6**, 126-139.
- Finke, R.A. and Kurtzman, H.S. (1981). Mapping the visual field in mental imagery. *Journal of Experimental Psychology: General*, **110**, 501-517.
- Finke, R.A. and Pinker, S. (1982). Spontaneous imagery scanning in mental extrapolation. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, **8**, 142-147.
- Finke, R.A. Pinker, S. and Farah, M.J. (1989). Reinterpreting visual patterns in mental imagery. *Cognitive Science*, **13**, 51-78.
- Finke, R.A. and Schmidt, M.J. (1977). Orientation-specific color aftereffects following imagination. *Journal of Experimental Psychology: Human Perception and Performance*, **3**, 599-606.
- Finke, R.A. and Schmidt, M.J. (1978). The quantitative measure of pattern representation in images using orientation-specific color aftereffects. *Perception and Psychophysics*, **23**, 515-520.
- Finke, R.A. and Slayton, K. (1988). Explorations of creative visual synthesis in mental imagery. *Memory and Cognition*, **16**, 252-257.
- Finke, R.A., Ward, T.M., and Smith, S.M. (1989). Reinterpreting visual patterns in mental imagery. *Cognitive Science*, **13**, 51-78.
- Finke, R.A., Ward, T.B. and Smith, S.M. (1992). *Creative Cognition: Theory, Research and Applications*. London: The MIT Press.
- Fleckenstein, K.S. (1992). The writer's eye on image: Revising for definition and depth. *Journal of Mental Imagery*, **16**, 109-117.
- Flew. A.G.N. (1964). Hume. In D.J.O'Connor (Ed.), *A Critical History of Western Philosophy*. New York: MacMillan Education Ltd.
- Flowers, J.H. and Garbin, C.P. (1989). Creativity and perception. In J.A.Glover, R.R.Ronning, and C.R.Reynolds (Eds.), *Handbook of Creativity: Perspectives on Individual Differences*. New York: Plenum Press. Pp.147-162.

- Forgays, D.G. and Forgays, D.K. (1992). Creativity enhancement through floatation isolation. *Journal of Environmental Psychology*, **12**, 329-335.
- Forisha, B.L. (1978). Mental imagery and creativity in men and women. *Perceptual and Motor Skills*, **47**, 1255-1264.
- Forisha, B.L. (1981). Patterns of creativity and mental imagery in men and women. *Journal of Mental Imagery*, **5**, 85-96.
- Forisha, B.L. (1983). Relationship between creativity and mental imagery: A question of cognitive style. In A.A.Sheik (Ed.) *Imagery, Current theory, Research and Application*. New York: Wiley.
- Foss, J.E. (1995). Materialism, reduction, replacement, and the place of consciousness in science. *Journal of Philosophy*, **XCII**, 401-429.
- Gackenbach, J. I. (1988). Psychological content of lucid versus non-lucid dreams. In J.I.Gackenbach and S. LaBerge (Eds.), *Conscious Mind, Sleeping Brain: Perspectives of Lucid Dreaming*. New York: Plenum. Pp. 181-220.
- Gardner, H. (1993) *Creating Minds. An anatomy of creativity seen through the lives of Freud, Einstein, Picasso, Stravinsky, Eliot, Graham, and Ghandi*. London: Harper Collins.
- Gardner, H. (1994). The creators' patterns. In M.A.Boden (Ed.), *Dimensions of Creativity*. London: MIT Press. Pp. 143-158.
- Ghiselin, B. (1952). *The Creative Process*. Berkeley: University of California Press.
- Gibson, J.J. (1950). *The Perception of the Visual World*. Boston: Houghton-Mifflin.
- Gibson, J.J. (1979). *The Ecological Approach to Visual Perception*. Boston: Houghton-Mifflin.
- Gilhooly, K.J. (1990). *Thinking. Directed, Undirected, and Creative* (second edition). London: Academic Press.
- Gick, M.L. and Holyoak, K.J. (1980). Analogical problem solving. *Cognitive Psychology*, **12**, 306-355.
- Glass (1978) In defense of generalisation. *The Behavioural and Brain Sciences*. **3**, 394-395.
- Glisky, M.L., Tataryn, D.J., and Kihlstrom, J.F. (1995). Hypnotizability and mental imagery. *The International Journal of Clinical and Experimental Hypnosis*, **43**, 34-54.

- Gonzalez, M.A., Campos, A., and Perez, M.J. (1997). Mental imagery and creative thinking. *The Journal of Psychology*, **131**, 357-364.
- Goodman, N. (1986). Pictures in the mind? In H.Barlow, C.Blakemore, and M.Weston-Smith (Eds.), *Images and Understanding: Thoughts about images, ideas about understanding*. Oxford: Oxford University Press.
- Goodwin, D.W. (1981). *Alcoholism. The Facts*. Oxford: Oxford University Press.
- Gordon, R. (1949). An investigation into some of the factors that favour the formation of stereotypes images. *British Journal of Psychology*, **39**, 156-167.
- Gordon, R. (1950). An experiment correlating the nature of imagery with performance on a test of reversal of perspective. *British Journal of Psychology*, **41**, 63-67.
- Green, C.I. (1968). *Lucid Dreams*. London: Hamish Hamilton.
- Green, C.I. & McCreery, C. (1994). *Lucid Dreaming. The paradox of consciousness during sleep*. London: Routledge.
- Gregory, R.L. (1966). *Eye and Brain: The psychology of seeing*. London:: Weidenfield
- Gregory, R.L. (1970). *The Intelligent Eye*. London: Weidenfield.
- Gregory, R.L. (1987). Illusions. In R.L.Gregory (Ed.) *The Oxford Companion to the Mind*. Oxford: Oxford University Press.
- Gruber, H.E. (1989). The evolving systems approach to creative work. In D.B. Wallace and H.E. Gruber (Eds.), *Creative People at Work*. New York: Oxford University Press. Pp. 3-24.
- Gruber, H.E. and Davis, S.N. (1988). Inching our way up Mount Olympus: the evolving systems approach to creative thinking. In R.J.Sternberg (Ed.), *The Nature of Creativity: Contemporary Psychological Perspectives*. Cambridge: Cambridge University Press. Pp. 243-270.
- Guilford, J.P. (1950). Creativity. *American Psychologist*, **5**, 444-454.
- Guilford, J.P. (1959). Traits of creativity. In H.Anderson (Ed.), *Creativity and its Cultivation*. London: Harper.
- Guilford, J.P. (1967). *The Nature of Human Intelligence*. New York: McGraw-Hill.
- Haber, R.N. (1979). Twenty years of haunting eidetic imagery: where's the ghost? *Behavioral and Brain Sciences*, **2**, 583-630.
- Hadamard, J.S. (1945). *The Psychology of Invention in the Mathematical Field*. Princeton: Princeton University Press.

- Hardy, L., Jones, G., and Gould, D. (1997). *Understanding Psychological Preparation for Sport. Theory and Practice of Elite Performers*. John Wiley & Sons. Chichester.
- Hargreaves, D.J. and Bolton, N. (1972). Selecting creativity tests for use in research. *British Journal of Psychology*, **63**, 451-462.
- Harnad, S. (1997). *Creativity: Method or Magic?* Internet publication.
- Harshman, R.A. and Paivio, A. (1987). Paradoxical sex differences in self-reported mental imagery. *Canadian Journal of Psychology*, **41**, 287-302
- Hartmann, E. (1975). Dreams and other hallucinations: an approach to the underlying mechanism. In R.K. Siegal and L.J. West (Eds.), *Hallucinations*. New York: Wiley.
- Hesse, M.B. (1964). Francis Bacon. In D.J.O'Connor (Ed.), *A Critical History of Western Philosophy*. London: MacMillan Education Ltd.
- Hilgard, E.R. (1973). A neodissociation interpretation of pain reduction in hypnosis. *Psychological Review*, **80**, 396-411.
- Hilgard, E.R. (1977). *Divided Consciousness. Multiple controls in human thought and action*. New York: John Wiley & Sons.
- Hilgard, E.R. (1979). *Personality and Hypnosis (second edition)*. Chicago: University of Chicago Press.
- Hilgard, E.R. (1992). Divided consciousness and dissociation. *Consciousness and Cognition*, **1**, 16-31.
- Hiscock, M. (1976). Effects of adjective imagery on recall from prose. *Journal of General Psychology*, **94**, 295-299.
- Hiscock, M. (1978). Imagery assessment through self-report: what do imagery questionnaires measure? *Journal of Consulting and Clinical Psychology*, **46**, 223-230.
- Hobson, J.A. (1988). *The Dreaming Brain*. London: Penguin Books.
- Hobson, J.A. (1998). Neuropsychology of dreaming consciousness. Presented at, *Toward a Science of Consciousness 1998 "Tuscon III"*. Tuscon, Arizona, April 27th to May 2nd.
- Hobson, J.A. & McCarley, R.W. (1977). The brain as a dream-state generator: An activation-synthesis hypothesis of the dream process. *American Journal of Psychiatry*, **134**, 1335-1368.
- Hocevar, D. (1979). Ideational fluency as a confounding factor in the measurement of originality. *Journal of Educational Psychology*, **71**, 191-196.

- Hocevar, D. and Bachelor, P. (1989). A taxonomy and critique of measurements used in the study of creativity. In J.A.Glover, R.R.Ronning, and C.R.Reynolds (Eds.). *Handbook of Creativity*. London: Plenum Press. Pp. 53-76.
- Holmes, D.S. (1984). Meditation and somatic arousal reduction: a review of the experimental evidence. *American Psychologist*, **39**, 1-10.
- Holmes (1990) The influence of meditation versus rest on physiological arousal: a second examination. In M.A.West (eds.), *The Psychology of Meditation*. Oxford: Clarendon Press. Pp. 81-103.
- Holt, R.R. (1964). Imagery: The return of the ostracized. *American Psychologist*, **19**, 254-264.
- Holyoak, K.J. and Koh, K. (1987). Surface and structural similarity in analogical transfer. *Memory and Cognition*, **15**, 332-340.
- Holzinger, B., Bolitschek, J., Saletu, B., Schmeiser-Rieder, A., Popovic, R. and Zeitlhofer, J. (1998). Sleep habits and subjective quality of life of lucid dreamers in Austria. Presented at, *Toward a Science of Consciousness 1998 "Tuscon III"*. Tuscon, Arizona, April 27th to May 2nd.
- Horowitz, M.J. (1970). *Image Formation and Cognition*. New York: Appleton-Century-Crofts.
- Inuzuka, M., Satoh, Y., & Wado, K. (1991). The imaginary companion: A questionnaire study. *Japanese Journal of Child and Adolescent Psychiatry*, **32**, 32-48.
- Hubbard, T.L. and Baird, J.C. (1988). Overflow, first-sight, and vanishing point distances in visual imagery. *Journal of Experimental Psychology*, **14**, 641-649.
- Intons-Peterson, M.J. (1983). Imagery paradigms: How vulnerable are they to experimenters' expectations? *Journal of Experimental Psychology: Human Perception and Performance*, **7**, 133-144.
- Intons-Peterson, M.J. and White, A.R. (1991). Experimenter Naiveté and imaginal judgments. *Journal of Experimental Psychology Human Perception and Performance*, **7**, 833-843.
- Isaac, A.R. and Marks, D.F. (1990). Mental practice applied to trampoline performance. In *Sport, Health, Psychology, and Exercise*. London: Sports Council.
- Isaac, A.R. and Marks, D.F. (1994). Individual differences in mental imagery experience: Developmental changes and specialization. *British Journal of Psychology*, **85**, 479-500.

- Isaac, A.R., Marks, D.F., and Russell, D.G. (1986). An instrument for assessing the imagery of movement. The Vividness of Movement Imagery Questionnaire. *Journal of Mental Imagery*, **10**, 23-30.
- Jackendoff, R. (1987). *Consciousness and the Computational Mind*. London: MIT Press.
- Jakes, S., and Hemsley, D.R. (1987). Personality reports of hallucination and imagery in a normal population. *Perceptual and Motor Skills*, **64**, 765-766.
- Jamison, R. (1993). *Touched with Fame*. New York: The Free Press.
- Jennings, J.L. (1991). Aphorisms and the creative imagination: Lessons in creativity, method, and communication. *Journal of Mental Imagery*, **15**, 11-133.
- Johnson, R.A. (1979). Creative imagery in blind and sighted adolescents. *Journal of Mental Imagery*, **3**, 23-30.
- Johnson, R.F., Maher, B.A. and Barber, T.X. (1972). Artifact in the 'essence of hypnosis': an evaluation of trance logic. *Journal of Abnormal Psychology*, **79**, 212-220.
- Johnson-Laird, P. (1993). *The Computer and the Mind. An Introduction to Cognitive Science*. Guernsey, Channel Islands: The Guernsey Press Co. Ltd.
- Jolicoeur, P. and Kosslyn, S.M. (1985). Is time to scan visual images due to demand characteristics? *Memory and Cognition*, **13**, 320-332.
- Julien, R.M. (1995). *A Primer of Drug Action (seventh edition)*. New York: W.H. Freeman & Co.
- Karmiloff-Smith, A. (1993). Is creativity domain-specific or domain-general? Clues from normal and abnormal development. *AISBQ*, **85**, 26-31.
- Kerr, N.H. (1993). Mental imagery, dreams, and perception. In C. Cavellero and D. Foulkes (Eds.), *Dreaming as Cognition*. London: Harvester Wheatsheaf.
- Khatena, J. (1972). The use of analogy in the production of original verbal images. *Journal of Creative Behavior*, **9**, 209-213.
- Khatena, J. (1973). Imagination imagery by children and the production of analogy. *Gifted Child Quarterly*, **17**, 98-102.
- Khatena, J. (1975). Relationship of autonomous imagery and creative self-perceptions. *Perceptual and Motor Skills*, **40**, 357-358.
- Khatena, J. (1978). Frontiers of creative imagination imagery. *Journal of Mental Imagery*, **2**, 33-46.

- Khatana, J. (1983). Analogy imagery and the creative imagination. *Journal of Mental Imagery*, **7**, 127-134.
- Kihlstrom, J.F. (1985). Hypnosis. *Annual Review of Psychology*, **36**, 385-418.
- Kihlstrom, J.F., Glisky, M.L., Peterson, M.A., Harvey, E.M., and Rose, P.M. (1991). Vividness and control of mental imagery: a psychometric analysis. *Journal of Mental Imagery*, **15**, 133-142.
- Kosslyn, S.M. (1973). Scanning visual images: Some structural implications. *Perception and Psychophysics*, **14**, 90-94.
- Kosslyn, S.M. (1975). Information representation in visual images. *Cognitive Psychology*, **7**, 341-370.
- Kosslyn, S.M. (1978). Measuring the visual angle of the mind's eye. *Cognitive Psychology*, **10**, 356-389.
- Kosslyn, S.M. (1980). *Image and Mind*. Cambridge, Mass.: Harvard University Press.
- Kosslyn, S.M. (1981). The medium and the message in mental image: A theory. *Psychological Review*, **88**, 46-66.
- Kosslyn, S.M. (1994). *Image and Brain: The resolution of the imagery debate*. Cambridge MA: MIT Press.
- Kosslyn, S.M., Ball, T.M., and Reiser, B.J. (1978). Visual images preserve metric spatial information: Evidence from studies of visual scanning. *Journal of Experimental Psychology: human Perception and Performance*, **4**, 47-60.
- Kosslyn, S.M. and Pomerantz, J.R. (1977). Imagery, propositions, and the form of internal representations. *Cognitive Psychology*, **9**, 52-76.
- Kosslyn, S.M., Reiser, M.J., Farah, M.J., and Fliegel, S.L. (1983). Generating visual images: units and relations. *Journal of Experimental Psychology: General*, **112**, 278-303.
- Kremer, J.M.D., and Scully, D.M. (1994). *Psychology in Sport*. USA: Taylor & Francis.
- Kripke, D.F., and Sonnenschein, D. (1978). A biologic rhythm in waking fantasy. In K.S.Pope and J.L.Singer (Eds.) *The Stream of Consciousness*. New York: John Wiley.
- Kuhn, T.S. (1970). *The Structure of Scientific Revolutions*. Chicago: University of Chicago Press.
- Kuzendorf, R.G. (1982). Mental images, appreciation of grammatical patterns. and creativity. *Journal of Mental Imagery*, **6**, 183-202.
- LaBerge, S. (1985). *Lucid Dreaming*. New York: J.P.Tarcher.

- LaBerge, S., and Gackenbach, J. (1986). Lucid dreaming. In B.B.Woolman and M.Ullman (Eds.) *Handbook of States of Consciousness*. New York: Van Nostrand Reinhold Company.
- LaBerge, S., Nagel, L., Dement, W., and Zarcone, V. (1981). Lucid dreaming verified by volitional communication during REM sleep. *Perceptual and Motor Skills*, **52**, 727-732.
- Lane, J.B. (1977). Problems in assessment of vividness and control of imagery. *Perceptual and Motor Skills*, **45**, 363-368.
- Lea, G. (1975). Chronometric analysis of the method of loci. *Journal of Experimental Psychology: Human Perception and Performance*, **1**, 95-104.
- Leighton, A. (1996). Visions revised. How solitary was the romantic genius? Books Features. *The Times Literary Supplement*, **4870**, 5-8.
- Lindauer, M.S. (1977). Imagery from the point of view of psychological aesthetics, the arts, and creativity. *Journal of Mental Imagery*, **2**, 343-362.
- Logie, R.H. (1986). Visuo-spatial processing in working memory. *The Quarterly Journal of Experimental Psychology*, **38A**, 229-247.
- Logie, R.H. (1995). *Visuo-Spatial Working Memory*. Hove: Lawrence Earlbaum Associates Ltd.
- Logie, R.H. and Baddeley, A.D. (1990) Imagery and working memory. In P.J.Hampson, D.F.Marks, and J.T.E.Richardson (Eds.), *Imagery. Current Developments*. London and New York: Routledge.
- Logie, R.H. and Marchetti, C. (1991). Visuo-spatial working memory: Visual, spatial or central executive. In R.H.Logie and M.Denis (Eds.), *Mental Images in Human Cognition*. London: Elsevier Science Publishers.
- Lorentz, H.A. (1895/1923). Michelson's interference experiment. In A.Sommerfield, W.Perrett and G.B.Jeffery (Trans.), *The Principle of Relativity. A collection of original memoirs on the special and general theory of relativity*. London: Dover Publications. Translated from, Versuch einer Theorie der elektrischen und optischen Ereunungen in bewegten Körpern. Leiden. Pp. 89-92.
- Lynn, S.J. and Rhue, J.W. (1986). The fantasy-prone person: hypnosis, imagination, and creativity. *Journal of Personality and Social Psychology*, **51**, 404-408.
- Maccoby, E.E. and Jacklin, C.N. (1974). *The Psychology of Sex Differences*. Stanford: Stanford University Press.

- Maisto, S.A., Galizio, M., and Connors, G.J. (1991). *Drug Use and Abuse. Third edition.* London: Harcourt Brace and Co.
- Marks, D.F. (1972). Individual differences in the vividness of visual imagery and their effect on function. In P.W. Sheehan (Ed.) *The Function and Nature of Mental Imagery.* New York: Academic Press. Pp. 83-108.
- Marks, D.F. (1973). Visual imagery differences in the recall of pictures. *British Journal of Psychology*, **64**, 17-24.
- Marks, D.F. (1977). Imagery and consciousness: a theoretical review from an individual differences perspective. *Journal of Mental Imagery*, **1**, 275-290.
- Marks, D.F. (1985). Imagery differences: an overview of research on visual imagery vividness. In D.F.Marks and D.G.Russell (Eds.), *Imagery I.* Dunedin, NZ: Human Performance Associates. Pp. 1-4.
- Marks, D.F. (1989). Bibliography of research utilizing the Vividness of Visual Imagery Questionnaire. *Perceptual and Motor Skills*, **69**, 707-718.
- Marks, D.F. (1990). On the relationship between imagery, body and mind. In P.J. Hampson, D.F. Marks, and J.T.E. Richardson (Eds.) *Imagery. Current Developments.* London: Routledge.
- Marks, D.F. (1995). New directions for mental imagery research. *Journal of Mental Imagery*, **3 & 4**, 153-167.
- Marks, D.F. (1998). Consciousness, mental imagery and action. Presented at *Toward a Science of Consciousness 1998 "Tuscon III"*. April 27th-May 2nd. Tuscon, Arizona.
- Marks, D.F. and Isaac, A.R. (1995). Topographical distribution of EEG activity accompanying visual and motor imagery in vivid and non-vivid imagers. *British Journal of Psychology*, **86**, 271-282.
- Marks, L.E. (1978). *The Unity of the Senses.* New York: Academic Press.
- Marks, L.E. (1982). Synaesthetic perception and poetic metaphor. *Journal of Experimental Psychology: Human Perception and Performance*, **8**, p. 15-23.
- Marks, D.F., Baird, J.M., and McKellar, P. (1989). Replication of trance logic using a modified experimental design: Highly hypnotizable subjects in both real and simulator groups. *The International Journal of Clinical and Experimental Hypnosis*, **37**, 232-248.
- Marr, D. (1982). *Vision: A computational investigation into the human representation and processing of visual information.* New York: Freeman.

- Marschark, M. (1985). Imagery and organization in the recall of prose. *Journal of Memory and Language*, **24**, 734-745.
- Marschark, M. and Reed-Hunt, R. (1989). A reexamination of the role of imagery in learning and memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, **15**, 710-720.
- Martindale, C. (1981). *Cognition and Consciousness*. Homeward: Tghe Dorsey Press.
- Mavromatis, A. (1987). *Hypnagogia. The unique state of consciousness between wakefulness and sleep*. London: Routledge.
- McDowell, D.M., and Kleber, H.D. (1994). MDMA: Its history and pharmacology. *Psychiatric Annuls*, **24**, p.127-131.
- McGuire, W.J. (1997). Creative hypothesis generating in psychology: Some useful heuristics. *Annual Review of Psychology*, **48**, 1-30.
- McKellar, P. (1957). *Imagination and Thinking*. New York: Basic Books.
- McKellar, P. (1972). Imagery from the standpoint of introspection. In P.W. Sheehan (Ed.) *The Function and Nature of Imagery*. New York and London: Academic Press. Pp. 33-63.
- McKellar, P. (1977). Autonomy, imagery and dissociation. *Journal of Mental Imagery*, **1**, 93-108.
- McKellar, P. (1987). Imagery and the unconscious. In D.F. Marks (Ed.) *Theories of Image Formation*. New York: Brandon House.
- McKellar, P. (1995). Creative imagination: hypnagogia and surrealism. *Journal of Mental Imagery*, **19**, 33-43.
- McKellar, P. (1997). Synaesthesia and imagery: Fantasia revisited. *Journal of Mental Imagery*, **21**, 41-55.
- McKelvie, S.J. (1994). Guidelines for judging psychometric properties of imagery questionnaires as research instruments: a quantative proposal. *Perceptual and Motor Skills*, **79**, 1219-1231.
- McKelvie, S.J. (1995). The VVIQ as a psychometric test of individual differences in visual imagery vividness: a critical quantative review and plea for direction. *Journal of Mental Imagery*, **19**, 1-106.
- McKelvie, S.J. and Gingrass, P.P. (1974). Reliability of two measures of visual imagery. *Perceptual and Motor Skills*, **39**, 417-418.

- McKelvie, S.J. and Rohrner, M.M. (1978). Individual differences in reported visual imagery and cognitive performance. *Perceptual and Motor Skills*, **46**, 451-458.
- Mednick, S.A. (1962). The associative basis of the creative process. *Psychological Review*, **69**, 220-232.
- Micheal, W.B. and Wright, C.R. (1989). Psychometric issues in the assessment of creativity. In J.A.Glover, R.R.Ronning, and C.R.Reynolds (Eds.), *Handbook of Creativity: Perspectives on Individual Differences*. New York: Plenum Press. Pp. 33-52.
- Miller, A.I. (1986). *Imagery in Scientific Thought: Creating twentieth Century Physics*. Cambridge, MA: MIT Press.
- Miller, A.I. (1989). Imagery and intuition in creative scientific thinking: Albert Einstein's invention of the special theory of relativity. In D.B. Wallace and H.E. Grubers (Eds.), *Creative People at Work*. New York: Oxford University Press. Pp. 171-188.
- Miller, A.I. (1992). Scientific creativity: A comparative study of Henri Poincaré and Albert Einstein. *Creativity Research Journal*, **5**, 385-418.
- Miller, L. (1978). Has artificial intelligence contributed to an understanding of the human mind? A critique of arguments for and against. *Cognitive Science*, **2**, 111-127.
- Miller, N.S. and Gold, M.S. (1994). LSD and ecstasy: Pharmacology, phenomenology, and treatment. *Psychiatric Annals*, **24**, 131-136.
- Miller, R. and Greenberg, R.A. (1981). *Poetry. An Introduction*. New York: St Martin's Press.
- Mitchell, D.B. and Richman, C.L (1980). Confirmed reservations: Mental travel. *Journal of Experimental Psychology: Human Perception and Performance*, **6**, 58-66.
- Montangero, J. (1993). Dreaming and creativity. In C.Cavellero and D.Foulkes (Eds.), *Dreaming as Cognition*. London: Harvester Wheatsheaf.
- Morris, P.E. and Hampson, P.J. (1983). *Imagery and Consciousness*. London: Academic Press.
- Moyer, R.S. and Bayer, R.H. (1976). Mental comparison and the symbolic distance effect. *Cognitive Psychology*, **8**, 228-246.
- Murray, N. (1994). Scientist of the strange. Poetry Features. *The Times Literary Supplement*, **4787**, 23-24.
- Naranjo, C. (1972/1990). The domain of meditation. In J.Pickering and M.Skinner (Eds.) *From Sentience to Symbols*. London: Harvester-Wheatsheaf. Pp 31-315.

- Newton, I. (1687/1981). Hypotheses and 'experimental philosophy'. In S.Brown, J.Fauvel, and R.Finnegan (Eds.), *Conceptions of Inquiry*. New York: Methuen & Co.
- O'Bryan-Doheny, M. (1993). Effects of mental practice on performance of a psychomotor skill. *Journal of Mental Imagery*, **17**, 111-118.
- Ochse, R. (1990). *Before the Gates of Excellence. The Determinants of Creative Genius*. Cambridge: Cambridge University Press.
- Orne, M.T. (1959). The nature of hypnosis: artifact and essence. *Journal of Abnormal and Social Psychology*, **58**, 277-299.
- Paivio, A. (1963). Learning of adjective-noun paired associates as a function of adjective-noun word order and noun abstractness. *Canadian Journal of Psychology*, **17**, 370-379.
- Paivio, A. (1969). Mental imagery in associative learning and memory. *Psychological Review*, **76**, 241-263.
- Paivio, A. (1971). *Imagery and Verbal Processes*. New York: Holt, Rinehart and Winston.
- Paivio, A. (1978a). Comparisons of mental clocks. *Journal of Experimental Psychology: Human Perception and Performance*, **4**, 61-71.
- Paivio, A. (1978b). Mental comparisons involving abstract attributes. *Memory & Cognition*, **6**, 199-208.
- Paivio, A. (1983). The mind's eye in arts and science. *Poetics*, **12**, 1-18
- Paivio, A. (1989). *Images in Mind. The Evolution of a Theory*. London: Harvester-Wheatsheaf.
- Paivio, A. and Madigan, S.A. (1968). Imagery and association value in paired-association learning. *Journal of Experimental Psychology*, **76**, 35-39.
- Paivio, A., Yuille, J.C. and Madigan, S. (1968). Concreteness, imagery, and meaningfulness values for 925 nouns. *Journal of Experimental Psychology Monograph Supplement*, **76**.
- Parrott, C.A. and Strongman, K.T. (1985). Utilization of visual imagery in creative performance. *Journal of Mental Imagery*, **9**, 53-66.
- Partington, J.R. (1964). *A History of Chemistry*. London: MacMillan & Co Ltd.
- Pavese, A. and Umiltà, C. (1998). Symbolic distance between numerosity and identity modulates stroop interference. *Journal of Experimental Psychology: Human Perception and Performance*, **24**, 1535-1545.

- Pekala, R.J. (1990). The phenomenology of meditation. In M.A.West (Ed.). *The Psychology of Meditation*. Oxford: Clarendon Press.
- Penrose, R. (1989). *The Emperor's New Mind*. Oxford: Oxford University Press.
- Perkins, D.N. (1994). Creativity: beyond the Darwinian paradigm. In M.A.Boden (Ed.). *Dimensions of Creativity*. London: MIT Press. Pp. 119-142.
- Peterson, M.A., Kihlstrom, J.F., Rose, P.M., and Glisky, M.L. (1992). Mental images can be ambiguous: Reconstruals and reference-frame reversals. *Memory and Cognition*, **20**, 107-123.
- Poincaré, H. (1952) Mathematical creation. In B.Ghiselin (Ed.), *The Creative Process*. Berkeley: University of California Press. Pp. 22-31.
- Post, F. (1994). Creativity and psychopathology: A study of 191 world famous men. *British Journal of Psychiatry*, **165**, 22-34.
- Pylyshyn, Z.W. (1973). What the mind's eye tells the mind's brain: A critique of mental imagery. *Psychological Bulletin*, **80**, 1-24.
- Pylyshyn, Z.W. (1981). The imagery debate: Analogue media versus tacit knowledge. *Psychological Review*, **88**, 16-45.
- Quinn, J.G. and McConnell, J. (1996). Irrelevant pictures in visual working memory. *Quarterly Journal of Experimental Psychology*, **49**, 200-215.
- Reed, G.F. (1979). Sensory deprivation. In G.Underwood & R.Stevens (Eds.) *Aspects of Consciousness. Volume 1: Psychological Issues*. London: Academic Press.
- Reed, S.K. (1992). *Cognition (third edition)*. Brooks/Cole Publishing Co., California.
- Reiber, L.P. (1995). A historical review of visualization in human cognition. *Educational, Technology Research and Development*, **43**, 45-56.
- Reiff, R. and Scheerer, M. (1959). *Memory and Hypnotic Age Regression*. New York: International Universities Press.
- Reisberg, D. and Hauer, F. (1988). Vividness, vagueness and the quantification of visualizing. *Journal of Mental Imagery*, **12**, 89-103.
- Reisberg, D and Morris, A. (1985). Images contain what the imager puts there: A non-replication of illusions in imagery. *Bulletin of the Psychonomic Society*, **23**, 493-496.
- Revonsuo, A. (1998). An evolutionary hypothesis of the function of dreaming. Presented at, *Toward a Science of Consciousness 1998 "Tuscon III"*. Tuscon. Arizona, April 27th to May 2nd.

- Riba, J. and Barbanoj, M.J. (1998). A pharmacological study of Ayahuasca in healthy volunteers. *Bulletin of the Multidisciplinary Association for Psychedelic Studies*, **8**, 12-15.
- Richardson, A. (1969). *Mental Imagery*. London: Routledge and Kegan Paul.
- Richardson, A. (1972). Voluntary control of the memory image. In P.W. Sheehan (Ed.), *The Function and Nature of Imagery*. New York: Academic Press, p. 109-129.
- Richardson, A. (1977). Verbalizer-visualizer: A cognitive style dimension. *Journal of Mental Imagery*, **2**, 109-125.
- Richardson, J.T.E. (1975). Concreteness and imageability. *Quarterly Journal of Experimental Psychology*, **27**, 235-249.
- Richardson, J.T.E. (1988). Vividness and unvividness: reliability, consistency, and validity of subjective imagery ratings. *Journal of Mental Imagery*, **12**, 115-122.
- Richardson, J.T.E. (1999). *Imagery*. Hove: Psychology Press.
- Richardson, J.T.E., & Mavromatis, A. (1985). The nature and function of hypnagogic memory. In D.F. Marks and D.G. Russell (Eds.) *Imagery I*. Proceedings of the First International Imagery Conference. Dunedin: Human Performance Associates. PP. 26-32.
- Richardson, J.T.E., Mavromatis, A., Mindel, T., & Owens, A.C. (1981). Individual differences in hypnagogic and hypnopompic imagery. *Journal of Mental Imagery*, **5**, 91-96.
- Richman, C.L., Mitchall, D.B., and Reznick, J.S. (1979). Mental travel: Some reservations. *Journal of Experimental Psychology: Human Perception and Performance*, **5**, 13-18.
- Rock, I. (1983). *The Logic of Perception*. London: Bradford Books. The MIT Press.
- Rosenthal, R. (1991). *Meta-analytic Procedures for Social Researchers*. London: Sage Publications.
- Rosenzweig, N. (1959). Sensory deprivation and schizophrenia: Some clinical and theoretical similarities. *American Journal of Psychiatry*, **116**, 326-29.
- Rossi, M.A. (1969). General methodological considerations. In J.P. Zubek (Ed.), *Sensory Deprivation: Fifteen Years of Research*. New York: Appleton-Century-Crofts.
- Rothenberg, A. (1979). *The Emerging Goddess: the creative process in art, science and other fields*. Chicago: University of Chicago Press.
- Rothenberg, A. (1995). Creative cognitive processes in Kekulé's discovery of the structure of the benzene molecule. *American Journal of Psychology*, **108**, 419-438.

- Rothenberg, A. and Sobel, R.S. (1980). Creation of literary metaphors as stimulated by superimposed versus separated visual images. *Journal of Mental Imagery*, **4**, 77-91.
- Rowley, D.T. (1986). *Hypnosis and Hypnotherapy*. London: The Charles Press.
- Rycroft, C. (1981). *The Innocence of Dreams*. Oxford: Oxford University Press.
- Sailor, K.M. and Shoben, E.J. (1993). Effects of category membership on comparative judgement. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, **19**, 1321-1327.
- Schaffer, S. (1994). Making up discovery. In M.A.Boden (Ed.), *Dimensions of Creativity*. London: MIT Press.
- Segal, S.J. and Fusella, V. (1970). Influence of imaged pictures and sounds on detection of visual and auditory symbols. *Journal of Experimental Psychology*, **83**, 458-464.
- Seligman, M.E.P. and Yellen, A. (1987). What is a dream?. *Behavioral Research and Therapy*, **25**, 1-24.
- Sergent, J. (1989). The neuropsychology of visual image generation: data, method and theory. *Brain and Cognition*, **13**, 98-129.
- Shapiro, D.H. (1985). Clinical use of meditation as a self-regulation strategy: comments on Holmes' conclusion and implications. *American Psychologist*, **40**, 719-722.
- Shannon, B. (1998). Ideas and reflections associated with Ayahuasca visions. *Bulletin of the Multidisciplinary Association for Psychedelic Studies*, **8**, 18-21.
- Shaw, G..A. and Belmore, S.M. (1982-1983). The relationship between imagery and creativity. *Imagination, Cognition and Personality*, **2**, 115-123.
- Shaw, G.A., and DeMers, S.T. (1986). The relationship of imagery to originality, flexibility and fluency in creative thinking. *Journal of Mental Imagery*, **10**, 65-74.
- Shaw, G.G. & Crossland, J. (1981). Hallucinogenic drugs and altered states of consciousness. In G.Underwood & R.Stevens (Eds.) *Aspects of Consciousness. Volume 2: Structural Issues*. London: Academic Press.
- Sheehan, P.W. (1967). A shortened form of Betts' Questionnaire upon mental Imagery. *Journal of Clinical Psychology*, **23**, 386-389.
- Sheehan, P.W., Obstoj, S.I., and McConkey, K. (1976). Trance logic and cue structure as supplied by the hypnotist. *Journal of Abnormal Psychology*, **85**, 459-472.
- Shepard, R.N. (1966). Learning and recall as organization and search. *Journal of Verbal Learning and Verbal Behavior*, **5**, 201-204.

- Shepard, R.N. (1978a). The mental image. *American Psychologist*, **33**, 125-137.
- Shepard (1978b). Externalization of mental images and the act of creation. In B.S.Randhawa and W.E.Coffman (Eds.), *Visual Learning, Thinking, and Communication*. New York: Academic Press.
- Shepard, R.N. (1984). Ecological constraints on internal representation: Resonant kinematics of perceiving, imagining, thinking, and dreaming. *Psychological Review*, **91**, 417-447.
- Shepard, R.N. and Metzler, J. (1971). Mental rotation of three-dimensional objects. *Science*, **171**, 701-703.
- Shoben, E.J., Cech, C.G., and Schwanenflugel, P.J. (1983). The role of subtractions and comparisons in comparative judgements involving numerical reference points. *Journal of Experimental Psychology: Human Perception and Performance*, **9**, 226-241.
- Shoben, E.J., Cech, C.G., Schwanenflugel, P.J., and Sailor, K.M. (1989). Serial position effects in comparative judgements. *Journal of Experimental Psychology: Human Perception and Performance*, **15**, 273-286.
- Shultz, G., and Melzack, R. (1991). The Charles Bonnet syndrome: 'phantom visual images'. *Perception*, **20**, 809-825.
- Singer, J.L. (1966). *Daydreaming: An Introduction to the Experimental Study of Inner Experience*. New York: Random House.
- Singer, J.L. (1975). *Daydreaming and Fantasy*. London: Allen and Unwin.
- Singer, J.L. and McCraven, V. (1961). Some characteristics of adult daydreaming. *Journal of Psychology*, **51**, 151-164.
- Singer, J.L., and Antrobus, J.S. (1972). Daydreaming, imaginal processes, and personality. In P.W.Sheehan (Ed.) *The Function and Nature of Mental Imagery*. New York: Academic Press. Pp. 175-202.
- Slee, J.A. (1988). Vividness as a descriptor and index of imagery. *Journal of Mental Imagery* **12**, 123-132.
- Smith, D.E. and Seymour, R.B. (1994). LSD: History and toxicity. *Psychiatric Annals*, **24**, 145-148.
- Sobel, R.S. and Rothenberg, A. (1980). Artistic creation as stimulated by superimposed versus separated visual images. *Journal of Personality and Social Psychology*, **39**, 953-961.

- Solso, R.L. (1991). *Cognitive Psychology (third edition)*. London: Allyn & Bacon.
- Spanos, N.P. (1983). The hidden observer as an experimental creation. *Journal of Personality and Social Psychology*, **44**, 170-176.
- Spanos, N.P. (1986). Hypnotic behavior: A social-psychological interpretation of amnesia, analgesia, and "trance logic". *Behavioral and Brain Sciences*, **9**, 449-502.
- Spanos, N.P., Ollerhead, V.G., and Gwynn, M.I. (1986). The effects of the three instructional treatments on pain magnitude and pain tolerance. *Imagination, Cognition and Personality*, **5**, 321-337.
- Spanos, N.P., Perlini, A.H., Patrick, L., Bell, S., and Gwynn, M.I. (1990). The role of compliance in hypnotic and non-hypnotic analgesia. *Journal of Research in Personality*, **24**, 433-453.
- Spender, S. (1952). The making of a poem. In B.Ghiselin (Ed.) *The Creative Process: A Symposium*. California: University of California Press. Pp. 113-126.
- Stein, B.S. (1989). Memory and Creativity. In J.A.Glover, R.R.Ronning, and C.R.Reynolds (Eds.), *Handbook of Creativity: Perspectives on Individual Differences*. New York: Plenum Press. Pp. 163-176.
- Sternberg, R.J. (1988). *The Nature of Creativity*, Cambridge: Cambridge University Press. Pp. 43-75.
- Storr, A. (1972). *The Dynamics of Creation*. London: Pelican Books Ltd.
- Strassman (1998). Perspectives on DMT research. *Bulletin of The Multidisciplinary Association for Psychedelic Studies*, **8**, 4-11.
- Suedfeld, P. (1969a) Introduction and historical background. J.P.Zubek (Ed.), *Sensory Deprivation: Fifteen Years of Research*. New York: Appleton-Century-Crofts. Pp 3-16
- Suedfeld, P. (1969b). Changes in intellectual performance and in susceptibility to performance. In J.P.Zubek (Ed.), *Sensory Deprivation: Fifteen Years of Research*. New York: Appleton-Century-Crofts. Pp 433-449.
- Suedfeld, P. (1980). *Restricted environmental stimulation: Research and clinical applications*. New York: Appleton-Century-Crofts.
- Suedfeld, P., Ballard, E.J., Baker-Brown, G., and Borrie, R.A. (1985-1986). 'Flow of consciousness in restricted environmental stimulation.' *Imagination, Cognition and Personality*, **5**, 219-231.

Suedfeld, P. and Best, J.A. (1977). Satiation and sensory deprivation combined in smoking therapy: Some case studies and unexpected side effects. *International Journal of the Addictions*, 13, 807-815.

Suedfeld, P. and Clarke, C.J. (1981). Specific food aversion acquired during restricted environmental stimulation. *Journal of Applied Psychology*, 11, 538-547.

Suedfeld, P., Metcalfe, J., and Bluck, S. (1987). Enhancement of scientific creativity by flotation rest (restricted environmental stimulation technique). *Journal of Environmental Psychology*, 7, 219-231.

Suedfeld, P., Steel, D., Wallbaum, A.B.C., Bluck, S., Livesy, N. and Capsozzi, L. (1994). Explaining the effects of stimulus restriction: Testing the dynamic hemispheric asymmetry hypothesis. *Journal of Environmental Psychology*, 14, 87-100.

Suler, J.R. (1980). Primary process thinking and creativity. *Psychological Bulletin*, 88, 144-165.

Sutcliffe, J.P., Perry, C.W., and Sheehan, P.W. (1970). Relation of some aspects of imagery and fantasy to hypnotic susceptibility. *Journal of Abnormal Psychology*, 76, 279-287.

Tabachnick, B.G. and Fidell, L.S. (1989). *Using Multivariate Statistics (second edition)*. New York: Harper Collins Publishers.

Tippett, L.J. (1992). The generation of visual images: A review of neuropsychological research and theory. *Psychological Bulletin*, 112, 415-432.

Torrance, E.P. (1972). Predicting validity of the Torrance Test of Creative Thinking. *Journal of Creative Behavior*, 6, 236-252.

Torrance, E.P. (1974). *Torrance Tests of Creative Thinking: Norms - technical manual*. Princeton: Personnel Press.

Torrance, E.P. (1988). The nature of creativity as manifest in 15 testings. In R.J. Sternberg (Ed.), *The Nature of Creativity*. Cambridge: Cambridge University Press. Pp. 43-75.

Tushup, R.J. and Zuckerman, M. (1977). The effects of stimulus invariance on daydreaming and divergent thinking. *Journal of Mental Imagery*, 2, 291-302.

Tweney, R.D. (1989). Fields of enterprise: On Michael Faraday's Thought. In D.B. Wallace & H.E. Gruber (Eds.), *Creative People at Work: 12 Cognitive Studies*. Oxford: Oxford University Press. Pp. 91-106.

- Ungerleider, S., Golding, J.M., Porter, K., and Foster, R. (1987). An exploratory examination of cognitive strategies used by master track and field athletes. *The Sports Psychologist*, **3**, 245-253.
- Valentine, E.R. (1992). *Conceptual Issues in Psychology (second edition)*. London: Routledge.
- Vardy, M.M. and Kay, S.R. (1998). LSD psychosis or LSD-induced schizophrenia? Internet publication
- Wagstaff, G.F. (1981). *Hypnosis, Compliance and Belief*. New York: St. Martin's Press.
- Walker, N.S., Garratt, J.B. and Wallace, B. (1976). Restoration of eidetic imagery via hypnotic age regression: a preliminary report. *Journal of Abnormal Psychology*, **85**, 335-337.
- Wallace, B. (1984). Apparent equivalence between perception and imagery in the production of various visual illusions. *Memory and Cognition*, **12**, 156-162.
- Wallace, B. (1990). Imagery vividness, hypnotic susceptibility, and the perception of fragmented stimuli. *Journal of Personality and Social Psychology*, **58**, 354-359.
- Wallace, B., Allen, P.A., and Weber, T.A. (1994). Hypnotic susceptibility, imaging ability, and the detection of embedded words within letters. *The International Journal of Clinical and Experimental Hypnosis*, **42**, 20-38.
- Wallach, M.A. and Kogan, N. (1965). *Modes of Thinking in Young Children: A Study of the Creativity-Intelligence distinction*. New York: Holt, Rinehart & Winston.
- Watson, J.B. (1913). Psychology as the behaviorist views it. *Psychological Review*, **20**, 158-177.
- Weisberg (1993). *Creativity: beyond the myth of genius*. New York: W.H. Freeman and Company.
- Weitzenhoffer, A.M., and Hilgard, E.R. (1959). *Stanford Hypnotic Susceptibility Scale, Forms A and B*. California: Consulting Psychologists Press.
- West, M.A. (1985). Meditation and somatic arousal reduction. *American Psychologist*, **40**, 717-719.
- West, M.A. (1990). Traditional and psychological perspectives on meditation. In M.A. West (Ed.), *The Psychology of Meditation*. Oxford: Clarendon Press. Pp 5-22.
- Westcott, T.B. and Rosenstock, E. (1976). Reliability of two measures of imagery. *Perceptual and Motor Skills*, **42**, 1037-1038.

- Wethearly, D.C., Ball, S.E., and Stacks, J.R. (1997). Reliance on visual imagery and its relation to mental rotation. *Perceptual and Motor Skills*, **85**, 431-434.
- White, K.D., Ashton, R., and Law, H. (1978). The measurement of imagery vividness: effects of format and order on the Betts' Questionnaire Upon Mental Imagery. *Canadian Journal of Behavioural Science*, **10**, 68-78.
- White, K., Sheehan, P.W., & Ashton, R. (1977). Imagery assessment: a survey of self-report measures. *Journal of Mental Imagery*, **1**, 145-169.
- Whitlock, F.A. (1987). Pseudohallucinations. In R.L. Gregory (Ed.) *The Oxford Companion to the Mind*. Oxford: Oxford University Press.
- Willingham, D.W. and Preuss, L. (1995). The death of implicit memory. *Psyche*, **2**, Internet publication.
- Wolpin, M., Marston, A., Randolph, C., and Clothier, A. (1992). Individual difference correlates of reported lucid dreaming frequency and control. *Journal of Mental Imagery*, **16**, 231-236.
- World Drug Report (1997). *World Drug Report. United Nations International Drug Control Programme*. Oxford: Oxford University Press.
- Yates, F.A. (1966). *The Art of Memory*. London: Routledge & Kegan Paul.
- Zangwill, O.L. (1987). Hypnosis, experimental. In R.L. Gregory (Ed.) *The Oxford Companion to the Mind*. Oxford: Oxford University Press.
- Zohar, D. (1990). *The Quantum Self*. London: Bloomsbury Publishing Ltd.
- Zubek, J.P. (1969). Sensory and perceptual processes. In J.P. Zubek (Ed.) *Sensory Deprivation: Fifteen years of research*. New York: Appleton-Century-Crofts. Pp 207-254.
- Zuckerman, M. (1969). Hallucinations, Reported sensations, and Images. In J.P. Zubek (Ed.) *Sensory Deprivation: Fifteen years of research*. New York: Appleton-Century-Crofts. Pp 407-433.

Appendix 5.6 The Test of Visual Imagery Control

Name:

Age:

Male or Female:

Occupation:

Read each question, then close your eyes while you try to visualize the scene described. Record your answer by underlining “Yes”, “No” or “Unsure”, whichever is the most appropriate. Remember that your accurate and honest answer to these questions is most important for the validity of this study. If you have any doubts at all regarding the answer to a question, underline “Unsure”. Please be sure that you answer each of the twelve questions.

- | | | | |
|--|-----|----|--------|
| 1. Can you see a car standing in the road in front of the house? | Yes | No | Unsure |
| 2. Can you see it in colour? | Yes | No | Unsure |
| 3. Can you see it in a different colour? | Yes | No | Unsure |
| 4. Can you now see the same car lying upside down? | Yes | No | Unsure |
| 5. Can you now see the same car back on its four wheels again? | Yes | No | Unsure |
| 6. Can you see the car running along the road? | Yes | No | Unsure |
| 7. Can you see it climb up a very steep hill? | Yes | No | Unsure |
| 8. Can you see it climb over the top? | Yes | No | Unsure |
| 9. Can you see it get out of control and crash through a house? | Yes | No | Unsure |
| 10. Can you now see the same car running along the road with a handsome couple inside? | Yes | No | Unsure |
| 11. Can you see the car cross a bridge and fall? over the side into a stream below? | Yes | No | Unsure |
| 12. Can you see the car all old and dismantled in a car cemetery? | Yes | No | Unsure |

Appendix 5.7. The Vividness of Poetry Imagery Questionnaire

The aim of the task is to assess your ability to create a mental picture of passages extracted from well known pieces of creative writing. The work has been specially selected for its use of language that evokes mental imagery. This is the realm of the five senses, where poetry requires the creation of perceptual representation. For example, much of the poetry written by the Lake Poets contains language that can be translated into a pictorial form:

*I wandered lonely as a cloud
that floats o'er vales and hills.*

William Wordsworth (1770-1850)

*For hope grew round me, like the twining vine,
And fruits, and foliage, not my own, seemed mine.*

Samuel Taylor Coleridge (1772-1834)

You will be asked to read each passage twice. The first time you will read the whole passage imagining the scenes as they come before you. The second reading will involve breaking the passage into elements that can be rated according to the imagery evoked. You are free to perform this task with your eyes open or closed - whatever is the most effective. You should rate the vividness of each image according to the rating scale given below. Refer to the rating scale after each response. Remember that your accurate response is vital. Finally, answer each question separately.

Rating scale

The image aroused by the item may be:

Perfectly clear and as vivid as normal vision	<u>1</u>	2	3	4	5
Clear and reasonably vivid	1	<u>2</u>	3	4	5
Moderately clear and vivid	1	2	<u>3</u>	4	5
Vague and dim	1	2	3	<u>4</u>	5
No image at all, you only "know" that	1	2	3	4	<u>5</u>

Task 1

The following passage is taken from a poem by Nikki Giovanni (1972) called the "Winter Poem". Your task is to read the poem and visualize the scenes that are conjured by the author:

*Once a snowflake fell
on my brow and i loved
it so much and i kissed
it and it was happy and called its cousins
and brothers and a web
of snow engulfed me then
i reached to love them all
and i squeezed them and they became
a spring rain and i stood perfectly
still and was a flower*

Nikki Giovanni (1943-)

Second Reading

Now try to create a mental picture of the poem. Attempt to visualize each aspect of the poem circling the most appropriate response as you do so:

Can you visualize:

1. A snowflake falling on to your brow?	1	2	3	4	5
2. A web of snow engulfing you?	1	2	3	4	5
3. Squeezing snow into spring rain?	1	2	3	4	5
4. Turning into a flower?	1	2	3	4	5

Rating scale

The image aroused by the item may be:

Perfectly clear and as vivid as normal vision	<u>1</u>	2	3	4	5
Clear and reasonably vivid	1	<u>2</u>	3	4	5
Moderately clear and vivid	1	2	<u>3</u>	4	5
Vague and dim	1	2	3	<u>4</u>	5
No image at all, you only "know" that	1	2	3	4	<u>5</u>

Task 2

The next passage is part of a poem written by Robert Herrick (1591-1674) called "To the Virgins, to Make Much of Time". Your task is to read the poem and visualize the scenes that are conjured by the author:

*Gather ye rosebuds while ye may,
Old time is still a-flying;
And this same flower that smiled today
Tomorrow will be dying.*

Robert Herrick (1591-1674)

Second Reading

Now try to create a mental picture of the poem. Attempt to visualize each aspect of the poem circling the most appropriate response as you do so:

Can you visualize:

1. Gathering rosebuds?	1	2	3	4	5
2. Old time flying?	1	2	3	4	5
3. A flower smiling?	1	2	3	4	5
4. A flower dying?	1	2	3	4	5

Rating scale

The image aroused by the item may be:

Perfectly clear and as vivid as normal vision	<u>1</u>	2	3	4	5
Clear and reasonably vivid	1	<u>2</u>	3	4	5
Moderately clear and vivid	1	2	<u>3</u>	4	5
Vague and dim	1	2	3	<u>4</u>	5
No image at all, you only "know" that	1	2	3	4	<u>5</u>

Task 3

The third piece of writing is taken from T.S.Eliot's, "The Love Song of J.Alfred Prufrock". Your task is to read the poem and visualize the scenes that are conjured by the author.

I have heard the mermaids singing, each to each.

I do not think they will sing to me.

*I have seen them ride seaward on the waves
Combing the white hair of the waves blown back
When the wind blows the water white and black.*

*We have lingered in the chambers of the sea
By seagirls wreathed with seaweed red and brown
Till human voices wake us, and we drown.*

T.S.Eliot (1888-1965)

Now try to create a mental picture of the poem. Attempt to visualize each aspect of the poem circling the most appropriate response as you do so:

Can you visualize:

1. Mermaids riding seaward on the waves?	1	2	3	4	5
2. Combing the white hair of the waves?	1	2	3	4	5
3. Seagirls wreathed with seaweed red and brown?	1	2	3	4	5
4. Being woken to drown?	1	2	3	4	5

Rating scale

The image aroused by the item may be:

Perfectly clear and as vivid as normal vision	<u>1</u>	2	3	4	5
Clear and reasonably vivid	1	<u>2</u>	3	4	5
Moderately clear and vivid	1	2	<u>3</u>	4	5
Vague and dim	1	2	3	<u>4</u>	5
No image at all, you only "know" that	1	2	3	4	<u>5</u>

Task 4

The final passage is taken from Richard Crashaw's, "An Epitaph upon a Young Married Couple Dead and Buried Together". Your task is to read the poem and visualize the scenes that are conjured by the author:

*And though they lie as they were dead,
their pillow stone, their sheets of lead,
Love made the bed; they'll take no harm.
Let them sleep: let them sleep on,
Till this stormy night be gone,
Till the eternal morrow dawn;
Then the curtains will be drawn
And they wake into a light,
Whose day shall never die in night.*

Richard Crashaw (1613-1694)

Second Reading

Now try to create a mental picture of the poem. Attempt to visualize each aspect of the poem circling the most appropriate response as you do so:

Can you visualize the lovers:

1. Dead?	1	2	3	4	5
2. Lying under a sheet of lead?	1	2	3	4	5
3. Sleeping through the stormy night?	1	2	3	4	5
4. Waking into a light?	1	2	3	4	5

Rating scale

The image aroused by the item may be:

Perfectly clear and as vivid as normal vision	<u>1</u>	2	3	4	5
Clear and reasonably vivid	1	<u>2</u>	3	4	5
Moderately clear and vivid	1	2	<u>3</u>	4	5
Vague and dim	1	2	3	<u>4</u>	5
No image at all, you only "know" that	1	2	3	4	<u>5</u>

**Appendix 5.8. Chronbach's Alpha Item-total Statistics for VPIQ
Contemporary Poetry (n=194).**

Item	Mean if Deleted	Variance if Item Deleted	Item Total Correlation	Alpha if Item Deleted
One	18.2917	29.1062	0.4606	0.7625
Two	17.6406	28.8388	0.3890	0.7714
Three	17.5052	27.5392	0.4271	0.7666
Four	16.7031	26.5135	0.4423	0.7659
Nine	17.8542	27.0048	0.5889	0.7421
Ten	17.4427	25.9967	0.5920	0.7387
Eleven	17.2706	26.2509	0.5528	0.7452
Twelve	16.9271	25.8166	0.4674	0.7622

**Appendix 5.9. Chronbach's Alpha Item-total Statistics for VPIQ
Traditional Epitaphic Poetry (n=194).**

Item	Mean if	Variance if	Item	Alpha if
	Item Deleted	Item Deleted	Correlation	Item Deleted
Thirteen	6.2500	6.9948	0.6251	0.6438
Fourteen	5.6719	6.6300	0.5307	0.7008
Fifteen	6.1979	7.3219	0.5891	0.6658
Sixteen	6.1302	7.7997	0.4416	0.7422

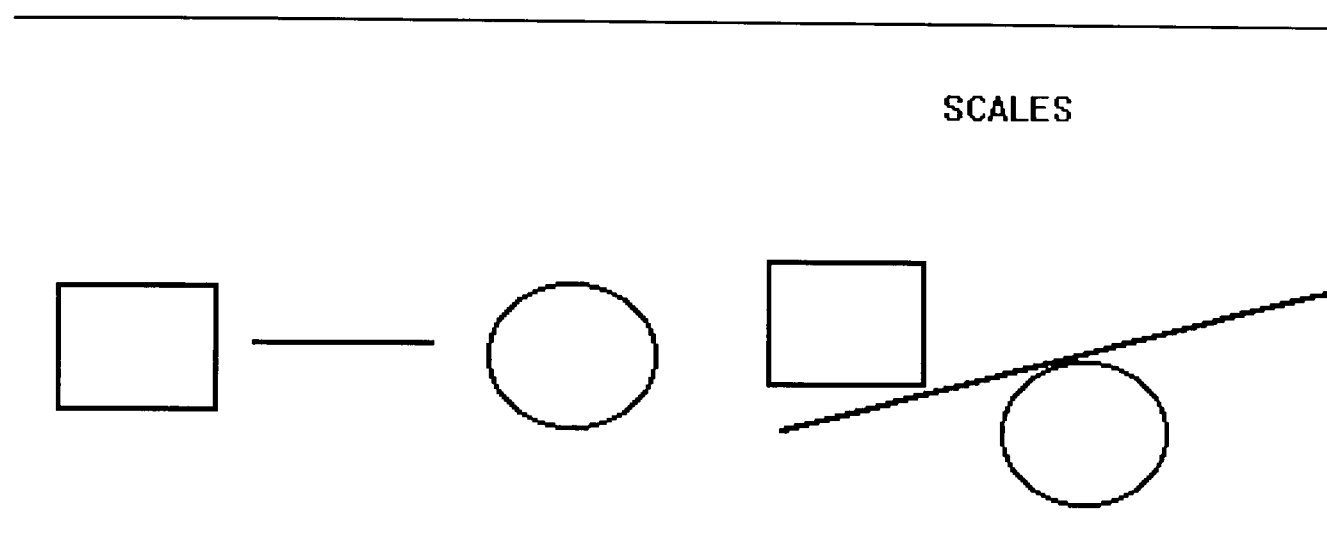
**Appendix 5.10. Chronbach's Alpha Item-total Statistics for VPIQ
Traditional Metaphoric Poetry (n=194).**

Item	Mean if	Variance if	Item	Alpha if
	Item Deleted	Item Deleted	Correlation	Item Deleted
Five	7.4896	7.4973	0.4750	0.6246
Six	6.1615	7.2879	0.3816	0.6918
Seven	7.0000	6.3979	0.5647	0.5614
Eight	7.8333	7.9825	0.5031	0.6169

Appendix 7.1. Instructions for the Pencil and Paper Version of the Creative Visualization Task

In this task you will be required to integrate three or more shapes/figures into a scene or object in as creative a way as possible. Once you have thought of a scene or an object write the title and draw a brief sketch to illustrate the use of the shapes/figures.

EXAMPLE



If you were given a square, a line, and a circle you could make some scales with a weight on the scales. Notice from the example that you are allowed to change the size of the shapes/figures. However, you are not allowed to change the basic shape. Thus, a circle cannot become an ellipse, a square an oblong, etc.. Finally you must use all the shapes/figures presented.

You have ten minutes to construct three possible scenes or objects from the parts presented on the following pages. Try to be as creative as possible.

Appendix 7.2. Scoring Instructions for the Pencil and Paper Version of the Creative Visualization Task

SCORING SHEET INSTRUCTIONS FOR CIT (Based on Finke and Slayton, 1988)

The aim of the Creative Integration Task is to integrate three or more shapes into an object or scene in as creative a way as possible. The participants are shown the shapes and are told to think of the object or scene, to write the title, and then to make a brief sketch to illustrate the use of the shapes. It is measured on the basis of three factors.

Factor One - number of Correct Responses

These are the number of responses that conformed to the rules of the task:

1. They integrated all of the given shapes.
2. They did not include any other shapes.
3. They provided a title
4. The object or scene fulfilled the minimal correspondence with the title

Factor Two - Correspondence Rating

As a judge it is your task to rate the correspondence between the drawing and the title. This judgement should not be made on the basis of the quality of the drawing but according to the patterns correspondence - had it been skillfully drawn. The following rating scale is to be used:

The correspondence of the pattern to the description is (circle the most appropriate response):

Very Good	Good	Average	Poor	Very Poor
5	4	3	2	1

Factor Three - Creativity

The final factor of interest is whether you regarded the mental synthesis as creative or not. Please indicate by ticking the appropriate responses:

Creative

Not Creative

Appendix 8.1. Digit-time only and arithmetic equivalents for the three symbolic distance conditions

Table I. Digit-time only and arithmetic equivalent scores for 30 degree difference (correct responses are placed on the left for convenience).

Angle ratio	Digit-time only		Arithmetic equivalent	
30-60	4.25	9.55	120:150	270:330
	6.35	10.00	180:210	300:360
	3.20	8.30	90:120	240:180
60-90	12.50	7.20	360:300	210:120
	5.15	6.15	150:90	180:90
	8.50	11.40	240:300	330:240
90-120	10.05	11.35	300:390	330:210
	9.30	12.20	270:180	360:480
	2.55	3.55	330:420	330:450
120-150	4.40	1.30	120:240	30:180
	12.20	2.35	360:480	60:210
	4.00	5.00	480:360	510:360

Table II. Digit-time only and arithmetic equivalent scores for 60 degree difference (correct responses are placed on the left for convenience).

Angle ratio	Digit-time only		Arithmetic equivalent	
30-90	1.10	12.45	30:60	360:270
	5.20	3.30	150:120	90:180
	8.35	4.05	240:210	120:30
	10.55	2.25	300:330	60:150
60-120	6.20	9.25	180:120	270:150
	7.45	10.30	210:270	300:180
	3.05	1.25	90:30	30:150
	2.20	6.50	60:120	180:300
90-150	12.15	7.00	360:450	210:360
	1.50	11.30	390:300	330:180
	2.25	5.50	60:150	150:300
	10.35	9.10	300:210	270:420

Table III. Digit-time only and arithmetic equivalent scores for 90 degree difference (correct responses are placed on the left for convenience).

Angle ratio	Digit-time only		Arithmetic equivalent	
30-120	3.10	6.10	90:60	180:60
	2.15	5.45	60:90	150:270
	12.05	8.20	360:390	240:120
	4.15	2.30	120:90	60:180
	7.40	10.10	210:240	300:420
	9.40	7.55	270:240	210:330
60-150	3.25	4.45	90:150	120:270
	9.35	8.05	270:210	240:390
	12.10	10.25	360:420	300:150
	10.40	2.45	300:240	420:270
	6.40	12.35	180:240	360:210
	2.00	6.05	60:00	180:30

Appendix 9.1.

THE SYMBOLIC EQUIVALENCE TEST

Name:

male/female:

Age:

Occupation:

In this test you will be asked to think of metaphors, or symbolically equivalent images, for certain suggested stimulus images. The task can best be made clear by an example.

Example:

Suggested stimulus image:

Leaves blown in the wind.

Possible symbolic equivalents:

A civilian population fleeing chaotically in the face of armed aggression.

Handkerchiefs being tossed about inside an electric dryer.

Chips of wood borne downstream by a swiftly eddying current.

You have 10 minutes to make up three possible equivalents for each of the five images presented on the following page:

a] A train going into a tunnel:

1)

2)

3)

b] A candle burning low:

1)

2)

3)

c] A ship lost in fog:

1)

2)

3)

d] Sitting alone in a dark room:

1)

2)

3)

e] Empty bookcases:

1)

2)

3)

You have 10 minutes to make up three possible equivalents for each of the five images presented on the following page:

a] Haystacks seen from a plane:

1) _____

2) _____

3) _____

b] The sound of a foghorn:

1) _____

2) _____

3) _____

c] A floating feather:

1) _____

2) _____

3) _____

d] The increasing loud and steady sound of a drum:

1) _____

2) _____

3) _____

e] Tall trees in the middle of a field:

1) _____

2) _____

3) _____

TEST DETAILS

The symbolic equivalence test was designed by F.Barron. The present form was derived from:

Barron, F. (1988). Putting creativity to work. In Sternberg, R.J. (Ed.), *The nature of creativity* (pp. 76-98). Cambridge: Cambridge University Press.

MARKING PROCEDURE

The test is scored on the basis of:

- 1) Number of acceptable, but not original, responses - grades 1.2 or 3 on the level of aptness.
- 2) Original responses - grades 4 or 5 according to degree of originality.
- 3) Scores summed over the 10 images.

Barron claims that the grading should be carried out by at least two markers and that a level of marking validity can be derived from comparison. It is also noted that the marking becomes more accurate with experience of using the test.

Here are some example marks from Barron (1988, pp. 87-88):

1. Stimulus image:

A candle burning low

Admissible responses:

Life ebbing away	(scored 1)
A basin of water emptying down a drain	(scored 2)
The last drops of coffee going through a filter	(scored 3)
The last pages of a faded book	(scored 4)
The last hand in a gambler's card game	(scored 5)

2) Stimulus image:

Empty bookcase:

Admissible responses:

A hollow log	(scored 1)
An empty sack	(scored 2)
An abandoned beehive	(scored 3)
An arsenal without weapons	(scored 4)
A haunted house	(scored 5)

Appendix 10.1. Pictorial Representations of the Symbolic Equivalence Task

Appendix 9.1.

THE SYMBOLIC EQUIVALENCE TEST

Name:

male/female:

Age:

Occupation:

In this test you will be asked to think of metaphors, or symbolically equivalent images, for certain suggested stimulus images. The task can best be made clear by an example.

Example:

Suggested stimulus image:

Leaves blown in the wind.

Possible symbolic equivalents:

A civilian population fleeing chaotically in the face of armed aggression.

Handkerchiefs being tossed about inside an electric dryer.

Chips of wood borne downstream by a swiftly eddying current.

Task 2

The next passage is part of a poem written by Robert Herrick (1591-1674) called "To the Virgins, to Make Much of Time". Your task is to read the poem and visualize the scenes that are conjured by the author:

*Gather ye rosebuds while ye may,
Old time is still a-flying;
And this same flower that smiled today
Tomorrow will be dying.*

Robert Herrick (1591-1674)

Second Reading

Now try to create a mental picture of the poem. Attempt to visualize each aspect of the poem circling the most appropriate response as you do so:

Can you visualize:

1. Gathering rosebuds?	1	2	3	4	5
2. Old time flying?	1	2	3	4	5
3. A flower smiling?	1	2	3	4	5
4. A flower dying?	1	2	3	4	5

Rating scale

The image aroused by the item may be:

Perfectly clear and as vivid as normal vision	<u>1</u>	2	3	4	5
Clear and reasonably vivid	1	<u>2</u>	3	4	5
Moderately clear and vivid	1	2	<u>3</u>	4	5
Vague and dim	1	2	3	<u>4</u>	5
No image at all, you only "know" that	1	2	3	4	<u>5</u>

Task 3

The third piece of writing is taken from T.S.Eliot's, "The Love Song of J.Alfred Prufrock".
Your task is to read the poem and visualize the scenes that are conjured by the author.

I have heard the mermaids singing, each to each.

I do not think they will sing to me.

*I have seen them ride seaward on the waves
Combing the white hair of the waves blown back
When the wind blows the water white and black.*

*We have lingered in the chambers of the sea
By seagirls wreathed with seaweed red and brown
Till human voices wake us, and we drown.*

T.S.Eliot (1888-1965)

Now try to create a mental picture of the poem. Attempt to visualize each aspect of the poem circling the most appropriate response as you do so:

Can you visualize:

1. Mermaids riding seaward on the waves?	1	2	3	4	5
2. Combing the white hair of the waves?	1	2	3	4	5
3. Seagirls wreathed with seaweed red and brown?	1	2	3	4	5
4. Being woken to drown?	1	2	3	4	5

Rating scale

The image aroused by the item may be:

Perfectly clear and as vivid as normal vision	<u>1</u>	2	3	4	5
Clear and reasonably vivid	1	<u>2</u>	3	4	5
Moderately clear and vivid	1	2	<u>3</u>	4	5
Vague and dim	1	2	3	<u>4</u>	5
No image at all, you only "know" that	1	2	3	4	<u>5</u>

Task 4

The final passage is taken from Richard Crashaw's, "An Epitaph upon a Young Married Couple Dead and Buried Together". Your task is to read the poem and visualize the scenes that are conjured by the author:

*And though they lie as they were dead,
their pillow stone, their sheets of lead,
Love made the bed; they'll take no harm.
Let them sleep: let them sleep on,
Till this stormy night be gone,
Till the eternal morrow dawn;
Then the curtains will be drawn
And they wake into a light,
Whose day shall never die in night.*

Richard Crashaw (1613-1694)

Second Reading

Now try to create a mental picture of the poem. Attempt to visualize each aspect of the poem circling the most appropriate response as you do so:

Can you visualize the lovers:

1. Dead?	1	2	3	4	5
2. Lying under a sheet of lead?	1	2	3	4	5
3. Sleeping through the stormy night?	1	2	3	4	5
4. Waking into a light?	1	2	3	4	5

Rating scale

The image aroused by the item may be:

Perfectly clear and as vivid as normal vision	<u>1</u>	2	3	4	5
Clear and reasonably vivid	1	<u>2</u>	3	4	5
Moderately clear and vivid	1	2	<u>3</u>	4	5
Vague and dim	1	2	3	<u>4</u>	5
No image at all, you only "know" that	1	2	3	4	<u>5</u>

Appendix 5.8. Chronbach's Alpha Item-total Statistics for VPIQ Contemporary Poetry (n=194).

Item	Mean if Deleted	Variance if Item Deleted	Item Total Correlation	Alpha if Item Deleted
One	18.2917	29.1062	0.4606	0.7625
Two	17.6406	28.8388	0.3890	0.7714
Three	17.5052	27.5392	0.4271	0.7666
Four	16.7031	26.5135	0.4423	0.7659
Nine	17.8542	27.0048	0.5889	0.7421
Ten	17.4427	25.9967	0.5920	0.7387
Eleven	17.2706	26.2509	0.5528	0.7452
Twelve	16.9271	25.8166	0.4674	0.7622

Appendix 5.9. Chronbach's Alpha Item-total Statistics for VPIQ Traditional Epitaphic Poetry (n=194).

Item	Mean if	Variance if	Item	Alpha if
	Item Deleted	Item Deleted	Correlation	Item Deleted
Thirteen	6.2500	6.9948	0.6251	0.6438
Fourteen	5.6719	6.6300	0.5307	0.7008
Fifteen	6.1979	7.3219	0.5891	0.6658
Sixteen	6.1302	7.7997	0.4416	0.7422

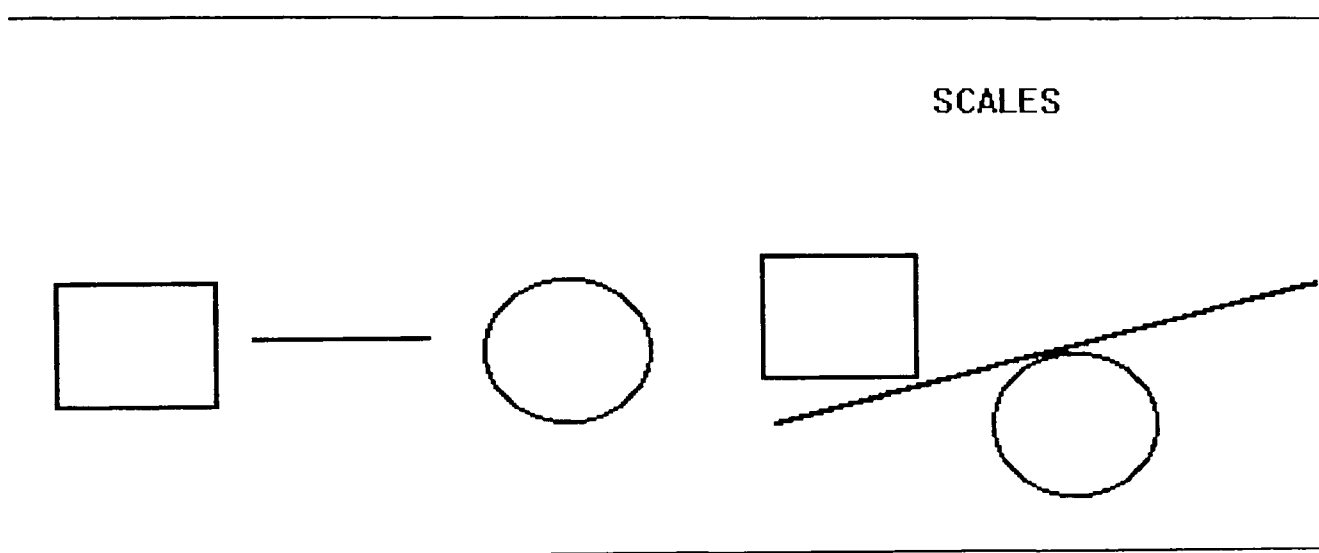
Appendix 5.10. Chronbach's Alpha Item-total Statistics for VPIQ Traditional Metaphoric Poetry (n=194).

Item	Mean if	Variance if	Item	Alpha if
	Item Deleted	Item Deleted	Correlation	Item Deleted
Five	7.4896	7.4973	0.4750	0.6246
Six	6.1615	7.2879	0.3816	0.6918
Seven	7.0000	6.3979	0.5647	0.5614
Eight	7.8333	7.9825	0.5031	0.6169

Appendix 7.1. Instructions for the Pencil and Paper Version of the Creative Visualization Task

In this task you will be required to integrate three or more shapes/figures into a scene or object in as creative a way as possible. Once you have thought of a scene or an object write the title and draw a brief sketch to illustrate the use of the shapes/figures.

EXAMPLE



If you were given a square, a line, and a circle you could make some scales with a weight on the scales. Notice from the example that you are allowed to change the size of the shapes/figures. However, you are not allowed to change the basic shape. Thus, a circle cannot become an ellipse, a square an oblong, etc.. Finally you must use all the shapes/figures presented.

You have ten minutes to construct three possible scenes or objects from the parts presented on the following pages. Try to be as creative as possible.

Appendix 7.2. Scoring Instructions for the Pencil and Paper Version of the Creative Visualization Task

SCORING SHEET INSTRUCTIONS FOR CIT (Based on Finke and Slayton, 1988)

The aim of the Creative Integration Task is to integrate three or more shapes into an object or scene in as creative a way as possible. The participants are shown the shapes and are told to think of the object or scene, to write the title, and then to make a brief sketch to illustrate the use of the shapes. It is measured on the basis of three factors.

Factor One - number of Correct Responses

These are the number of responses that conformed to the rules of the task:

1. They integrated all of the given shapes.
2. They did not include any other shapes.
3. They provided a title
4. The object or scene fulfilled the minimal correspondence with the title

Factor Two - Correspondence Rating

As a judge it is your task to rate the correspondence between the drawing and the title. This judgement should not be made on the basis of the quality of the drawing but according to the patterns correspondence - had it been skillfully drawn. The following rating scale is to be used:

The correspondence of the pattern to the description is (circle the most appropriate response):

Very Good	Good	Average	Poor	Very Poor
5	4	3	2	1

Factor Three - Creativity

The final factor of interest is whether you regarded the mental synthesis as creative or not. Please indicate by ticking the appropriate responses:

Creative

Not Creative

Appendix 8.1. Digit-time only and arithmetic equivalents for the three symbolic distance conditions

Table I. Digit-time only and arithmetic equivalent scores for 30 degree difference (correct responses are placed on the left for convenience).

Angle ratio	Digit-time only		Arithmetic equivalent	
30-60	4.25	9.55	120:150	270:330
	6.35	10.00	180:210	300:360
	3.20	8.30	90:120	240:180
60-90	12.50	7.20	360:300	210:120
	5.15	6.15	150:90	180:90
	8.50	11.40	240:300	330:240
90-120	10.05	11.35	300:390	330:210
	9.30	12.20	270:180	360:480
	2.55	3.55	330:420	330:450
120-150	4.40	1.30	120:240	30:180
	12.20	2.35	360:480	60:210
	4.00	5.00	480:360	510:360

Table III. Digit-time only and arithmetic equivalent scores for 90 degree difference (correct responses are placed on the left for convenience).

Angle ratio	Digit-time only		Arithmetic equivalent	
30-120	3.10	6.10	90:60	180:60
	2.15	5.45	60:90	150:270
	12.05	8.20	360:390	240:120
	4.15	2.30	120:90	60:180
	7.40	10.10	210:240	300:420
	9.40	7.55	270:240	210:330
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	9.35	8.05	270:210	240:390
	12.10	10.25	360:420	300:150
	10.40	2.45	300:240	420:270
	6.40	12.35	180:240	360:210
	2.00	6.05	60:00	180:30

You have 10 minutes to make up three possible equivalents for each of the five images presented on the following page:

a] A train going into a tunnel:

1) _____

2) _____

3) _____

b] A candle burning low:

1) _____

2) _____

3) _____

c] A ship lost in fog:

1) _____

2) _____

3) _____

d] Sitting alone in a dark room:

1) _____

2) _____

3) _____

e] Empty bookcases:

1) _____

2) _____

3) _____

You have 10 minutes to make up three possible equivalents for each of the five images presented on the following page:

a) Haystacks seen from a plane:

1) _____

2) _____

3) _____

b) The sound of a foghorn:

1) _____

2) _____

3) _____

c) A floating feather:

1) _____

2) _____

3) _____

d) The increasing loud and steady sound of a drum:

1) _____

2) _____

3) _____

e) Tall trees in the middle of a field:

1) _____

2) _____

3) _____

TEST DETAILS

The symbolic equivalence test was designed by F.Barron. The present form was derived from:

Barron, F. (1988). Putting creativity to work. In Sternberg, R.J. (Ed.). *The nature of creativity* (pp. 76-98). Cambridge: Cambridge University Press.

MARKING PROCEDURE

The test is scored on the basis of:

- 1) Number of acceptable, but not original, responses - grades 1,2 or 3 on the level of aptness.
- 2) Original responses - grades 4 or 5 according to degree of originality.
- 3) Scores summed over the 10 images.

Barron claims that the grading should be carried out by at least two markers and that a level of marking validity can be derived from comparison. It is also noted that the marking becomes more accurate with experience of using the test.

Here are some example marks from Barron (1988, pp. 87-88):

1. Stimulus image:
A candle burning low

Admissible responses:

- | | |
|---|------------|
| Life ebbing away | (scored 1) |
| A basin of water emptying down a drain | (scored 2) |
| The last drops of coffee going through a filter | (scored 3) |
| The last pages of a faded book | (scored 4) |
| The last hand in a gambler's card game | (scored 5) |

- 2) Stimulus image:
Empty bookcase:

Admissible responses:

- | | |
|----------------------------|------------|
| A hollow log | (scored 1) |
| An empty sack | (scored 2) |
| An abandoned beehive | (scored 3) |
| An arsenal without weapons | (scored 4) |
| A haunted house | (scored 5) |

Appendices

Appendix 4.1 Evaluations of Effect Size, Power, and Sample Size Requirements in 6 Studies of the Association Between Self-reported Imagery and Creativity.

Study	Imagery Measure	Creativity Measure	N	Effect Size	Power of Study	Predicted Sample Size*
B (1978)	VVIQ	St. Consequences	32	0.49	0.9281	22
C & P (1989)	VES	TTCT Fig. Fluency	122	0.24	0.8578	103
" " " "	" "	TTCT Fig. Flex.	122	0.23	0.8291	113
" " " "	" "	TTCT Fig. Orig.	122	0.14	0.4634	311
" " " "	" "	TTCT Fig. Elab.	122	0.21	0.7624	136
F (1981)	BQMI	TTCT Verb. Flu.	320	0.12	0.8578	425
" "	" "	TTCT Verb. Flex.	320	Not Reported ----- Non-Significant		
" "	" "	TTCT Verb. Orig.	320	Not Reported ----- Non-Significant		
" "	TVIC	TTCT Verb. Flu.	320	0.15	0.8562	270
" "	" "	TTCT Verb. Flex.	320	0.20	0.9772	150
" "	" "	TTCT Verb. Orig.	320	0.18	0.9476	187
P & S (1985)	VVIQ	TTCT Verb. Flu.	70	Not Reported ----- Non-Significant		
" " " "	" "	TTCT Verb. Flex.	70	Not Reported ----- Non-Significant		
" " " "	" "	TTCT Verb. Orig.	70	Not Reported ----- Non-Significant		
" " " "	" "	TTCT Verb. Total.	70	Not Reported ----- Non-Significant		
" " " "	" "	TTCT Fig. Flu.	70	0.31	0.8546	60
" " " "	" "	TTCT Fig. Flex.	70	Not Reported ----- Non-Significant		
" " " "	" "	TTCT Fig. Elab.	70	0.34**	0.9116	63
" " " "	TVIC	TTCT Verb. Flu.	70	Not Reported ----- Non-Significant		
" " " "	" "	TTCT Verb. Flex.	70	Not Reported ----- Non-Significant		
" " " "	" "	TTCT Verb. Orig.	70	Not Reported ----- Non-Significant		
" " " "	" "	TTCT Verb. Total	70	Not Reported ----- Non-Significant		
" " " "	" "	TTCT Fig. Flu.	70	Not Reported ----- Non-Significant		
" " " "	" "	TTCT Fig. Orig.	70	Not Reported ----- Non-Significant		
" " " "	" "	TTCT Fig. Elab.	70	0.34	0.9116	49

S & B (1982-83)	VVIQ	RAT	67	0.19	0.4692	167
" " " "	" "	TTCT Verb. Total	67	0.24	0.6397	103
" " " "	" "	TTCT Fig. Total	67	0.29	0.7909	69
<hr/>						
S & D (1986)	VVIQ	TTCT Verb. Flu	84	0.14	0.3701	311
" " " "	" "	TTCT Verb. Flex.	84	0.005	-----	-----
" " " "	" "	TTCT Verb. Orig	84	0.076	-----	-----
" " " "	" "	TTCT Fig. Flu.	84	0.38	0.9816	39
" " " "	" "	TTCT Fig. Flex.	84	0.18	0.4921	187
" " " "	" "	TTCT Fig. Orig	84	0.131	0.3286	356
" " " "	TVIC	TTCT Verb. Flu	84	0.179	0.05035	189
" " " "	" "	TTCT Verb. Flex.	84	0.046	-----	-----
" " " "	" "	TTCT Verb. Orig	84	0.062	-----	-----
" " " "	" "	TTCT Fig. Flu.	84	0.292	0.8708	68
" " " "	" "	TTCT Fig. Flex.	84	0.021	-----	-----
" " " "	" "	TTCT Fig. Orig	84	0.001	-----	-----

Appendix 5.1.Vividness of Visual Imagery Questionnaire

Eyes Open

Visual imagery refers to the ability to visualize, that is, the ability to form mental pictures, or to "see in the mind's eye". Marked individual differences have been found in the strength and clarity of reported visual imagery and these differences are of considerable psychological interest.

The aim of this test is to determine the vividness of your visual imagery. The items of the test will possibly bring certain images to your mind. You are asked to rate the vividness of each image by reference to the 5-point scale given below. For example, if your image is "vague and dim" then give it a rating of 4. Before you turn to the items on the next page, familiarize yourself with the different categories on the rating scale. Throughout the test, refer to the rating scale when judging the vividness of each image. Try to do each item separately, independent of how you have done other items. Complete all items for images obtained with the eyes open.

Rating Scale

The image aroused by the item might be:

Perfectly clear and as vivid as normal vision	<u>1</u>	2	3	4	5
Clear and reasonably vivid	1	<u>2</u>	3	4	5
Moderately clear and vivid	1	2	<u>3</u>	4	5
Vague and dim	1	2	3	<u>4</u>	5
No image at all, you only "know" that you are thinking of an object	1	2	3	4	<u>5</u>

In answering items 1 to 4 think of some relative or friend whom you frequently see (but who is not with you at present) and consider carefully the picture that comes before your mind's eye.

Item

1. The exact contour of face, head, shoulders and body.	1	2	3	4	5
2. Characteristic poses of head, attitudes of body, etc.	1	2	3	4	5
3. The precise carriage, length of step, etc. in walking.	1	2	3	4	5
4. The different colours worn in some familiar clothes.	1	2	3	4	5

Visualize the rising sun. Consider carefully the picture that comes before your mind's eye.

Item

5. The sun is rising above the horizon into a hazy sky.	1	2	3	4	5
6. The sky clears and surrounds the sun with blueness	1	2	3	4	5
7. Clouds. A storm blows up, with flashes of lightening.	1	2	3	4	5
8. A rainbow appears.	1	2	3	4	5

Rating Scale

The image aroused by the item might be:

Perfectly clear and as vivid as normal vision	<u>1</u>	2	3	4	5
Clear and reasonably vivid	1	<u>2</u>	3	4	5
Moderately clear and vivid	1	2	<u>3</u>	4	5
Vague and dim	1	2	3	<u>4</u>	5
No image at all, you only "know" that you are thinking of an object	1	2	3	4	<u>5</u>

Think of the front of a shop you often go to. Consider the picture that comes before your mind's eye.

Item

9. The overall appearance of the shop from the opposite side of the road.

1 2 3 4 5

10. A window display including colours, shapes and details of individual items for sale.

1 2 3 4 5

11. You are near the entrance. The colour, shape and details of the door.

1 2 3 4 5

12. You enter the shop and go to the counter. The counter assistant serves you. Money changes hands.

1 2 3 4 5

Finally, think of a country scene which involves trees, mountains and a lake. Consider the picture that comes before your mind's eye.

Item

13. The contours of the landscape

1 2 3 4 5

14. The colour and shape of the tree

1 2 3 4 5

15. The colour and shape of the lake

1 2 3 4 5

16. A strong wind blows on the trees and on the lake causing waves.

1 2 3 4 5

Rating Scale

The image aroused by the item might be:

Perfectly clear and as vivid as normal vision

1 2 3 4 5

Clear and reasonably vivid

1 2 3 4 5

Moderately clear and vivid

1 2 3 4 5

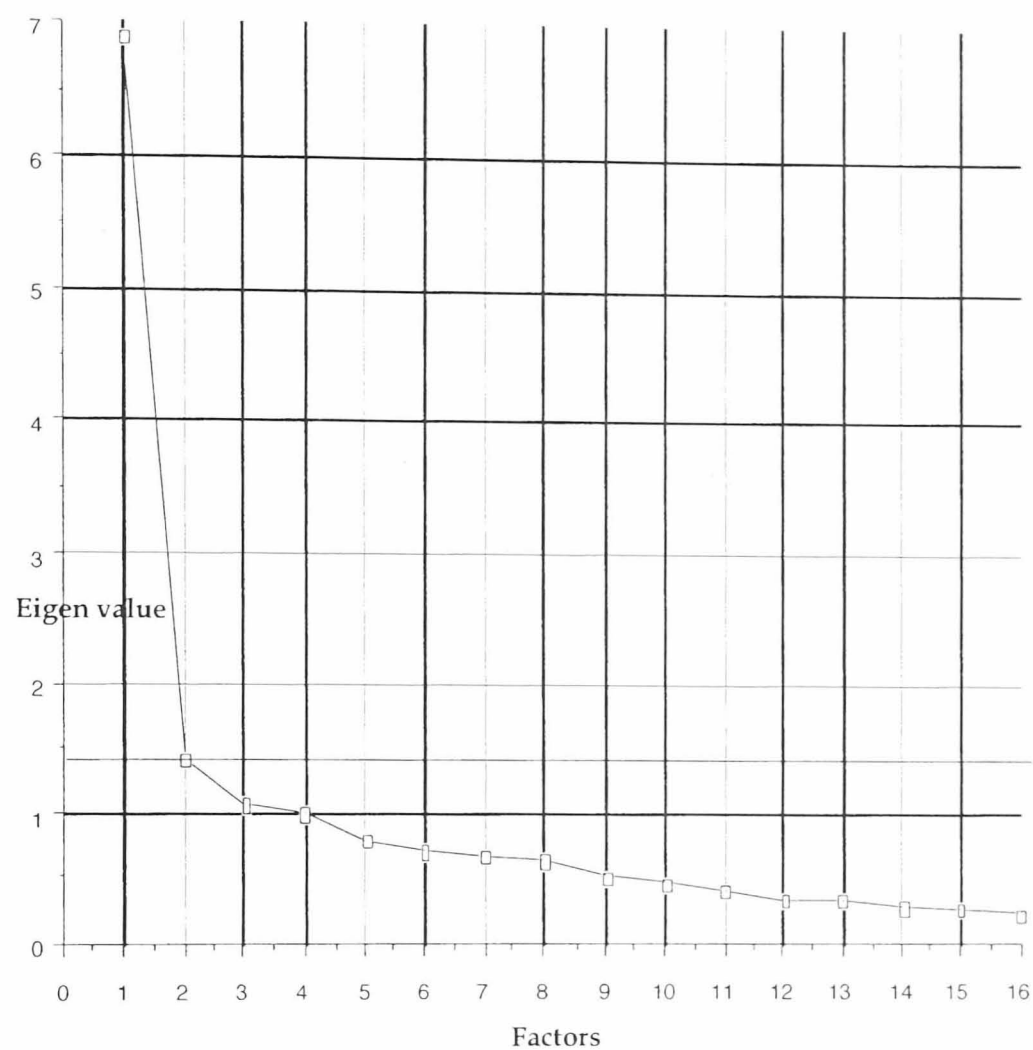
Vague and dim

1 2 3 4 5

No image at all, you only "know" that

1 2 3 4 5

Appendix 5.2. Scree Plot of Factors Emerging following a PCA on the Eye-open Version of the VVIQ (n=198)



**Appendix 5.3. Chronbach's Alpha Item-total Statistics for VVIQ Nature Scenes
(n=198)**

Item	Mean if Item Deleted	Variance if Item deleted	Item correlation	Alpha if item deleted
Five	16.8939	32.4405	0.5794	0.8610
Six	16.9444	33.2304	0.4885	0.8712
Seven	16.7980	32.2940	0.5698	0.8658
Eight	16.8232	33.7673	0.4735	0.8764
Thirteen	16.7828	33.7648	0.5259	0.8667
Fourteen	16.8458	34.4439	0.4965	0.8706
Fifteen	16.8737	32.1261	0.5715	0.8615
Sixteen	16.7273	33.4988	0.4161	0.8718

Alpha = 0.8827

Standardised Item Alpha = 0.8841

Appendix 5.4. Chronbach's Alpha Item-total Statistics for VVIQ Person Scenes (n=198)

Item	Mean if Item Deleted	Variance if Item deleted	Item correlation	Alpha if item deleted
One	6.6970	6.2833	0.4729	0.7298
Two	6.6126	6.1869	0.4649	0.7303
Three	5.9343	5.8586	0.4288	0.7364
Four	6.7222	6.4453	0.2532	0.8088

Alpha = 0.8017

Standardised Item Alpha = 0.8052

**Appendix 5.5. Chronbach's Alpha Item-total Statistics for VVIQ Shop Scenes
(n=198)**

Item	Mean if Item Deleted	Variance if Item deleted	Item correlation	Alpha if item deleted
Nine	7.0960	5.5694	0.4096	0.6666
Ten	6.5202	5.5199	0.3427	0.7020
Eleven	6.6869	5.6833	0.3005	0.7160
Twelve	7.3182	6.4008	0.2761	0.7368

Alpha = 0.7625

Standardised Item Alpha = 0.7631

Appendix 5.6 The Test of Visual Imagery Control

Name:

Age:

Male or Female:

Occupation:

Read each question, then close your eyes while you try to visualize the scene described. Record your answer by underlining "Yes", "No" or "Unsure", whichever is the most appropriate. Remember that your accurate and honest answer to these questions is most important for the validity of this study. If you have any doubts at all regarding the answer to a question, underline "Unsure". Please be sure that you answer each of the twelve questions.

- | | | | |
|--|-----|----|--------|
| 1. Can you see a car standing in the road in front of the house? | Yes | No | Unsure |
| 2. Can you see it in colour? | Yes | No | Unsure |
| 3. Can you see it in a different colour? | Yes | No | Unsure |
| 4. Can you now see the same car lying upside down? | Yes | No | Unsure |
| 5. Can you now see the same car back on its four wheels again? | Yes | No | Unsure |
| 6. Can you see the car running along the road? | Yes | No | Unsure |
| 7. Can you see it climb up a very steep hill? | Yes | No | Unsure |
| 8. Can you see it climb over the top? | Yes | No | Unsure |
| 9. Can you see it get out of control and crash through a house? | Yes | No | Unsure |
| 10. Can you now see the same car running along the road with a handsome couple inside? | Yes | No | Unsure |
| 11. Can you see the car cross a bridge and fall? over the side into a stream below? | Yes | No | Unsure |
| 12. Can you see the car all old and dismantled in a car cemetery? | Yes | No | Unsure |

Appendix 5.7. The Vividness of Poetry Imagery Questionnaire

The aim of the task is to assess your ability to create a mental picture of passages extracted from well known pieces of creative writing. The work has been specially selected for its use of language that evokes mental imagery. This is the realm of the five senses, where poetry requires the creation of perceptual representation. For example, much of the poetry written by the Lake Poets contains language that can be translated into a pictorial form:

*I wandered lonely as a cloud
that floats o'er vales and hills.*

William Wordsworth (1770-1850)

*For hope grew round me, like the twining vine,
And fruits, and foliage, not my own, seemed mine.*

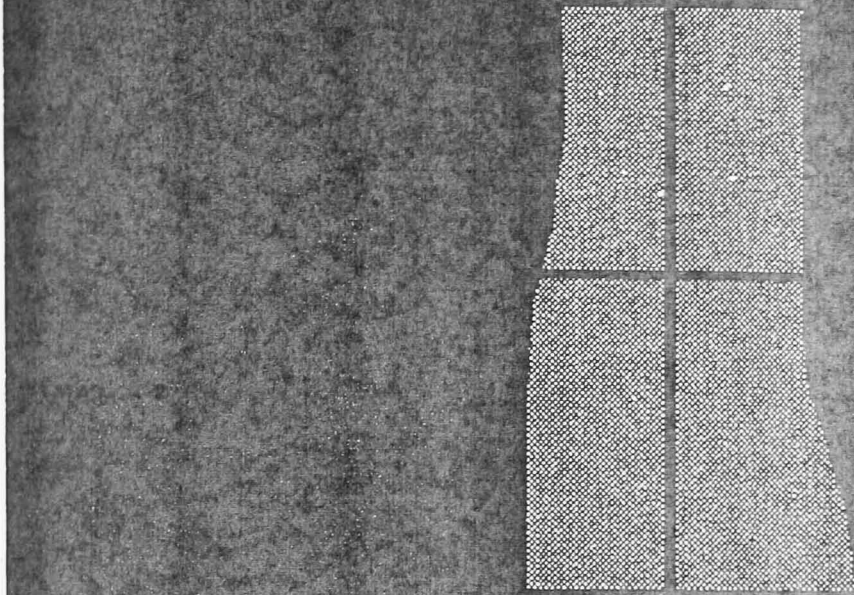
Samuel Taylor Coleridge (1772-1834)

You will be asked to read each passage twice. The first time you will read the whole passage imagining the scenes as they come before you. The second reading will involve breaking the passage into elements that can be rated according to the imagery evoked. You are free to perform this task with your eyes open or closed - whatever is the most effective. You should rate the vividness of each image according to the rating scale given below. Refer to the rating scale after each response. Remember that your accurate response is vital. Finally, answer each question separately.

Rating scale

The image aroused by the item may be:

Perfectly clear and as vivid as normal vision	<u>1</u>	2	3	4	5
Clear and reasonably vivid	1	<u>2</u>	3	4	5
Moderately clear and vivid	1	2	<u>3</u>	4	5
Vague and dim	1	2	3	<u>4</u>	5
No image at all, you only "know" that	1	2	3	4	<u>5</u>



Sitting Alone in a Dark Room

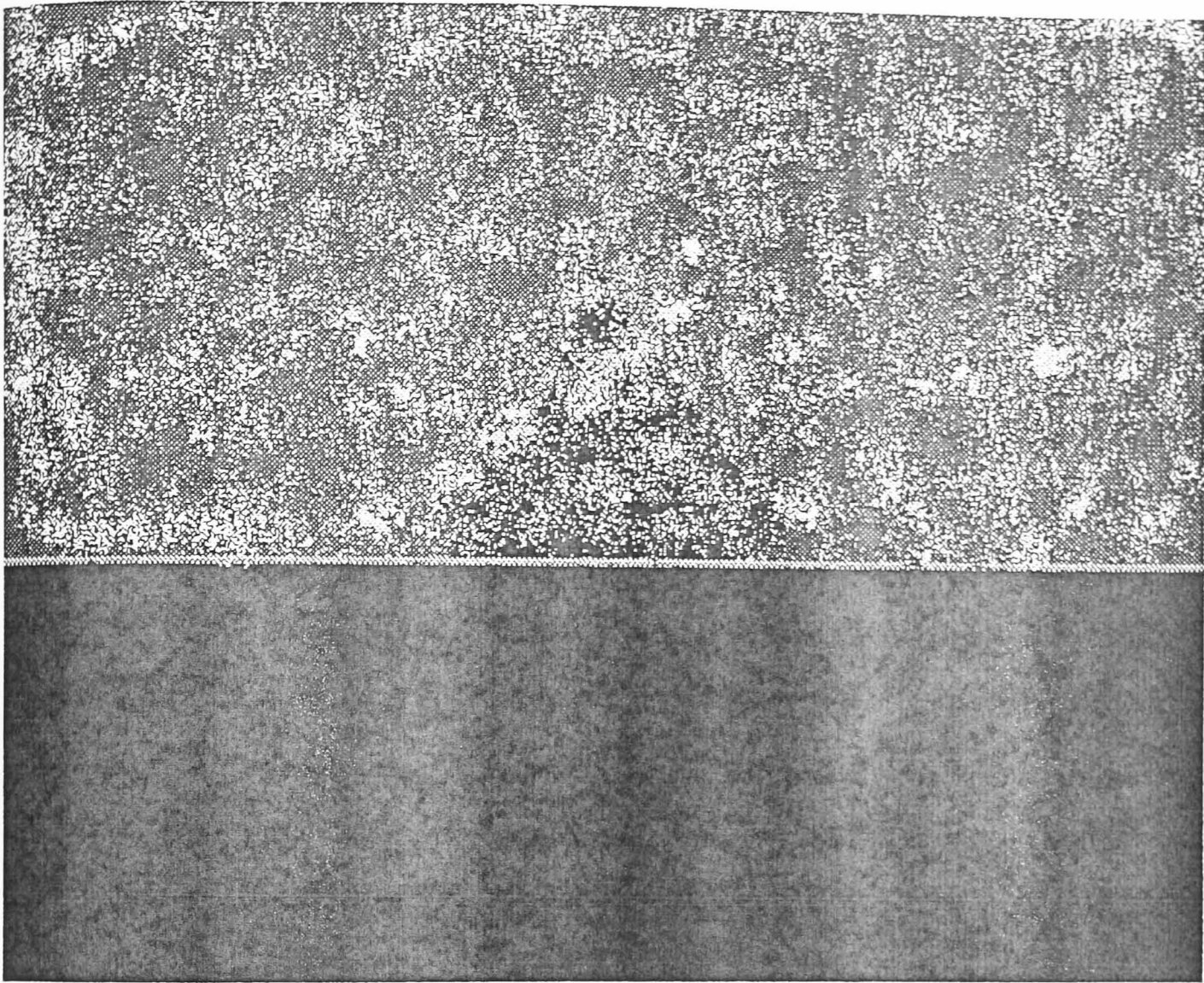
1.

2.

3.

4.

5.



A Ship lost in Fog

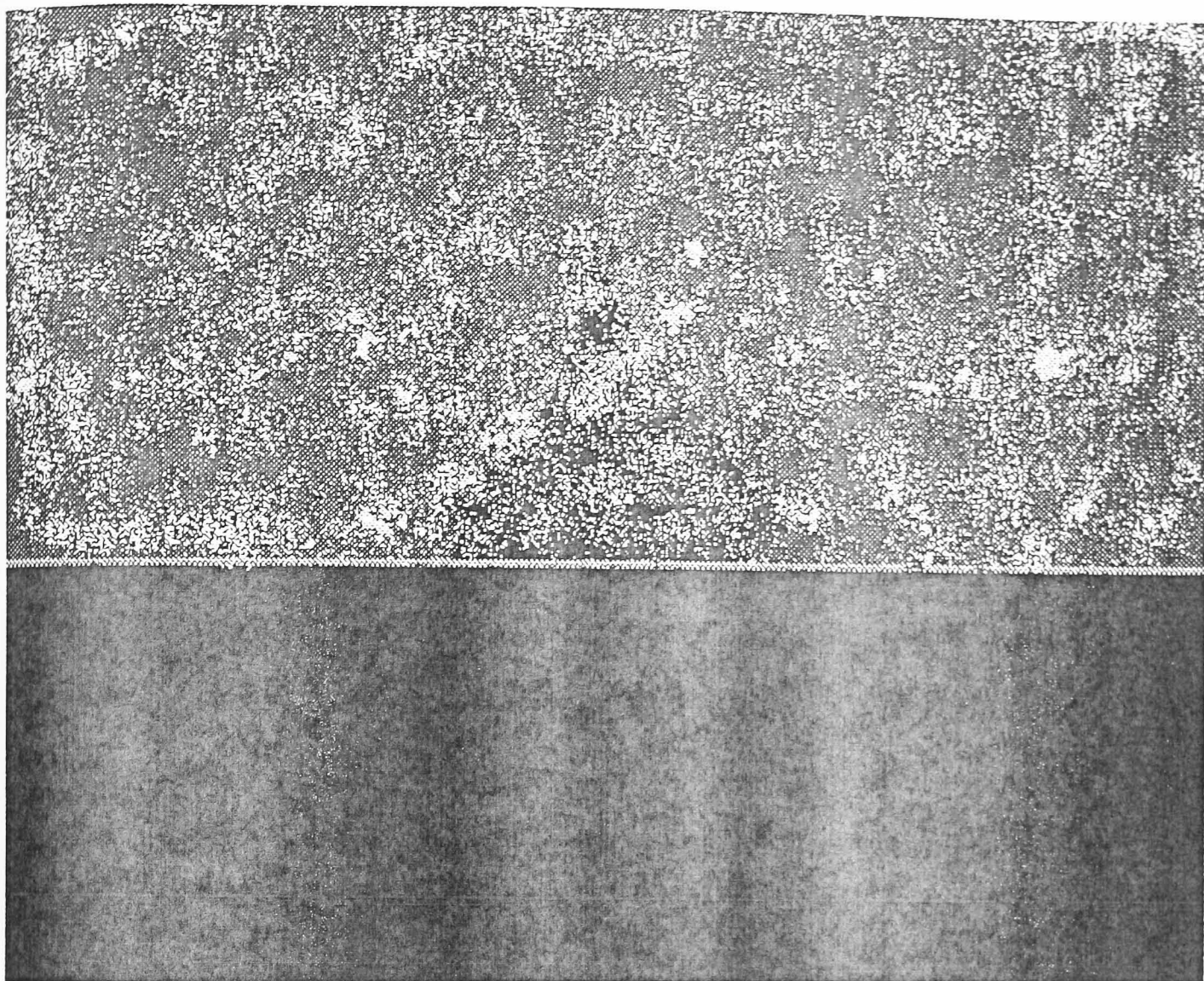
1.

2.

3.

4.

5.



A Ship lost in Fog

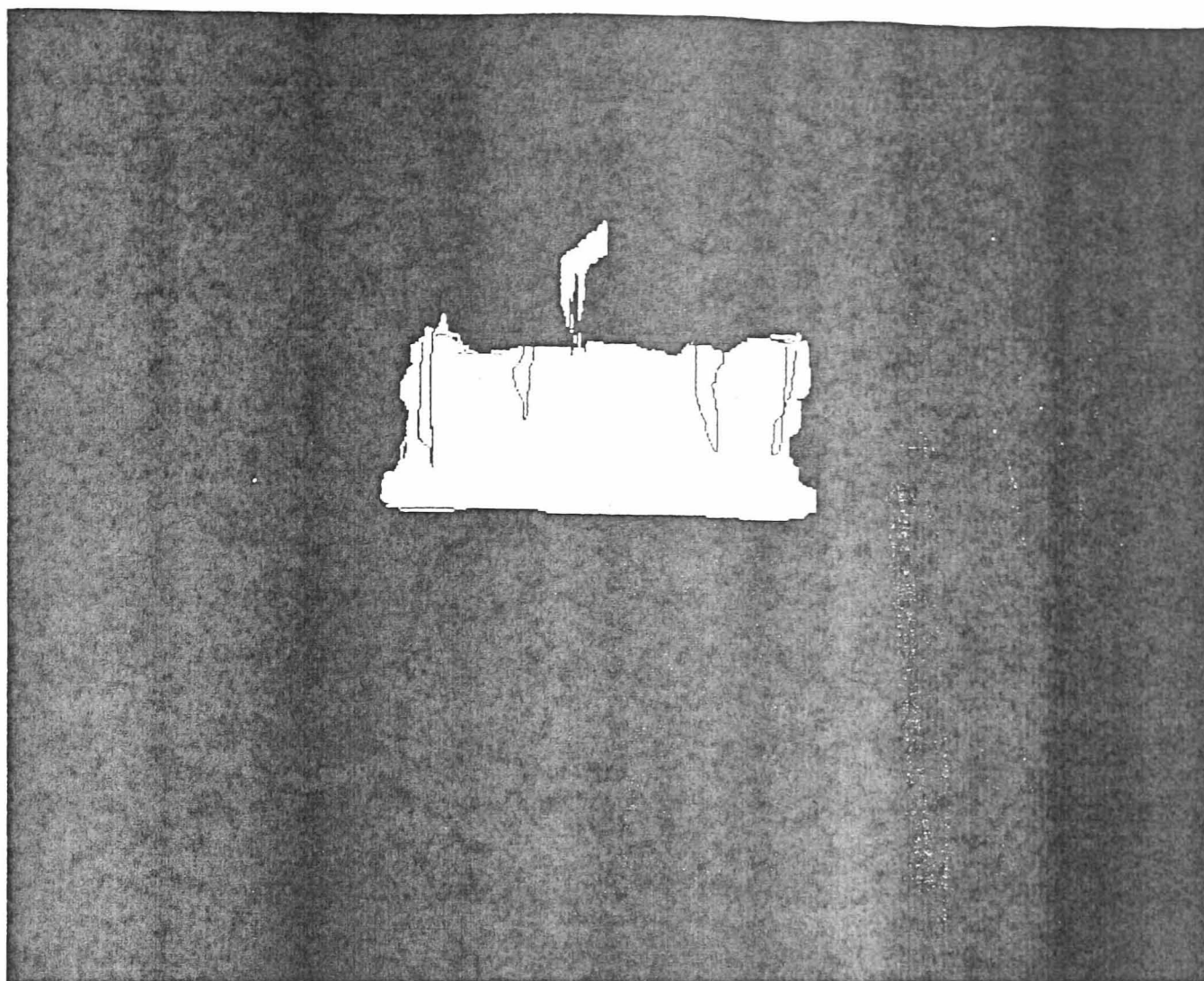
1.

2.

3.

4.

5.



A candle burning low

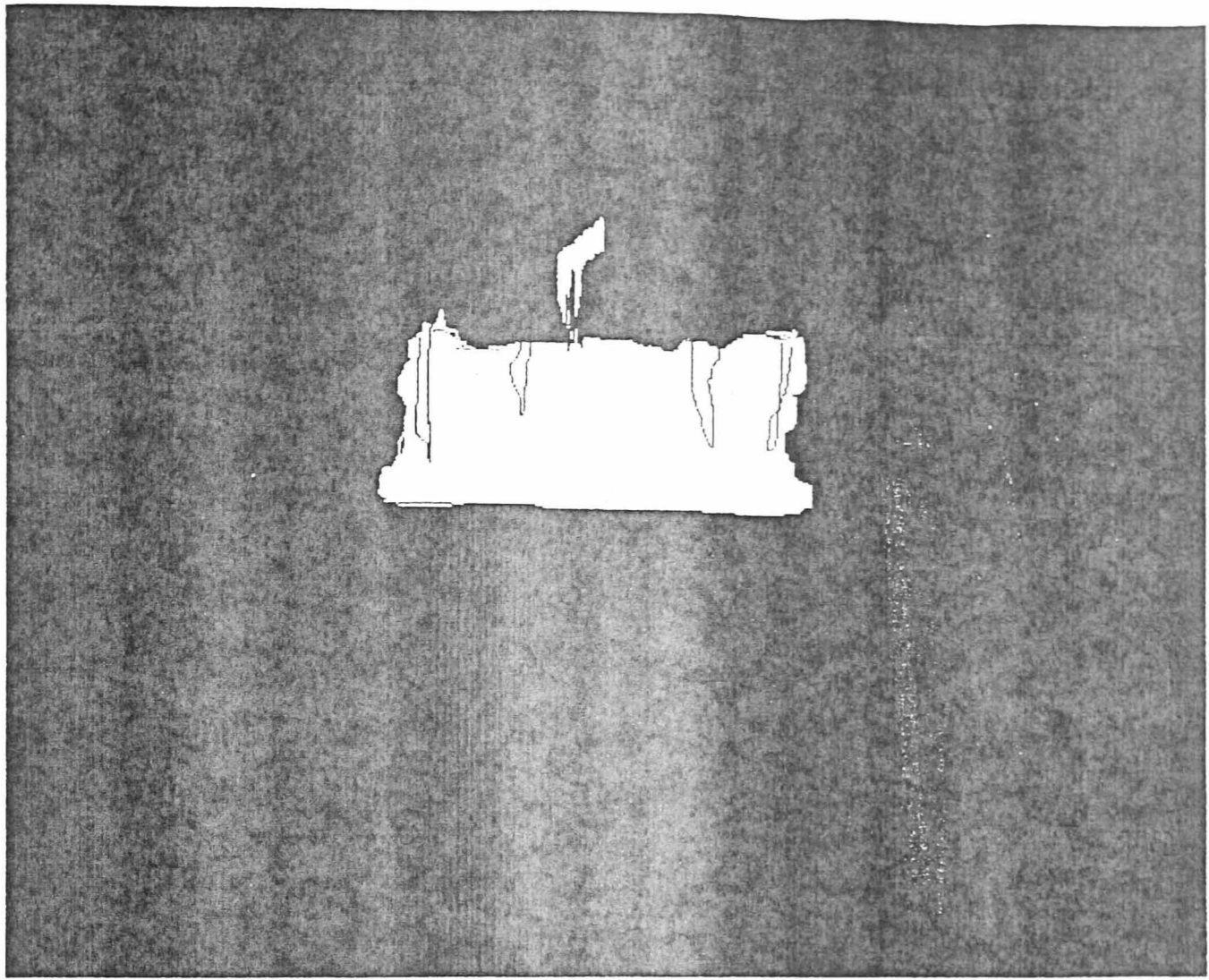
1.

2.

3.

4.

5.



A candle burning low

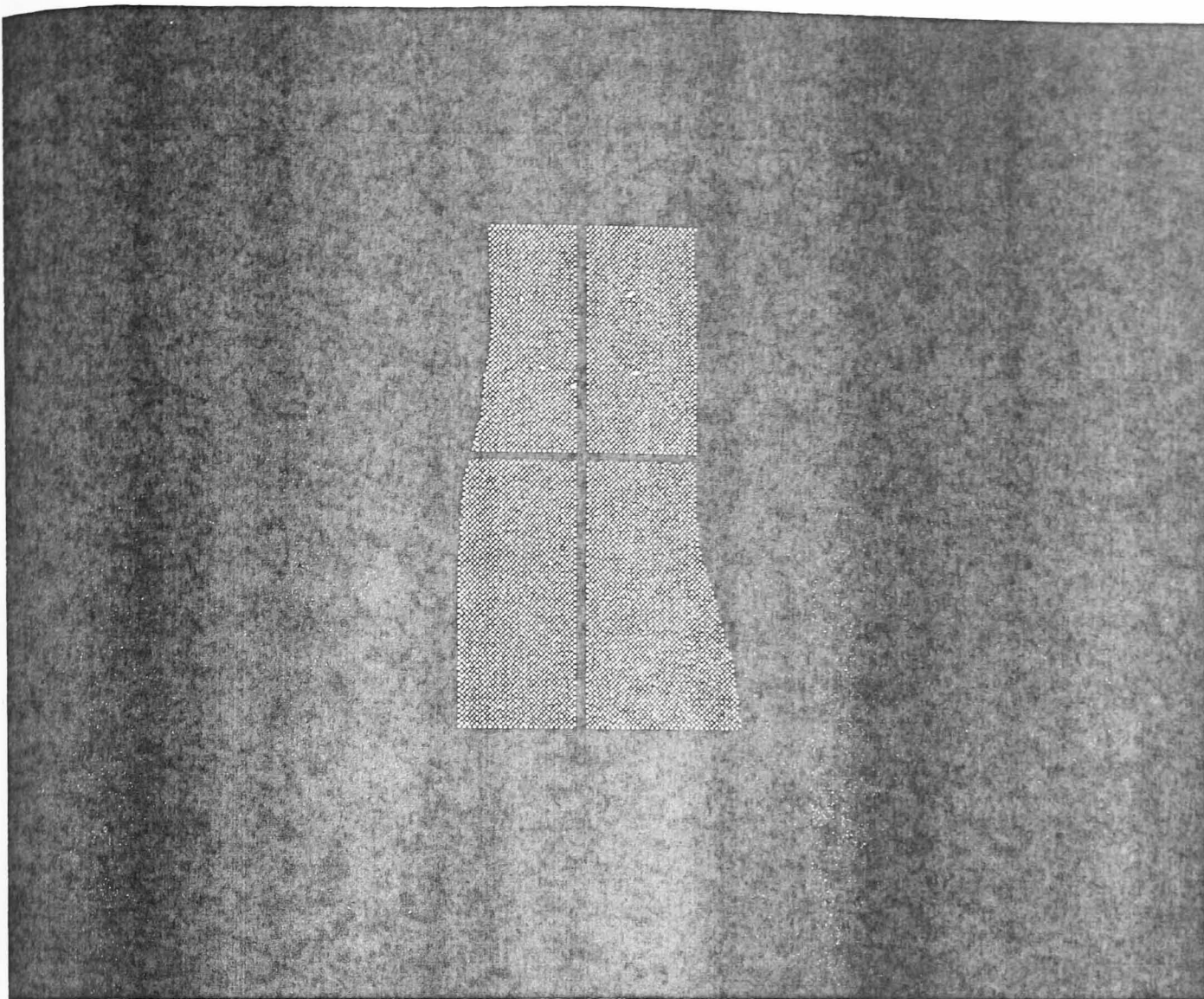
1.

2.

3.

4.

5.



Sitting Alone in a Dark Room

1.

2.

3.

4.

5.



Tall Trees in the Middle of a Field

1.

2.

3.

4.

5.



Tall Trees in the Middle of a Field

1.

2.

3.

4.

5.

Task 1

The following passage is taken from a poem by Nikki Giovanni (1972) called the “Winter Poem”. Your task is to read the poem and visualize the scenes that are conjured by the author:

*Once a snowflake fell
on my brow and i loved
it so much and i kissed
it and it was happy and called its cousins
and brothers and a web
of snow engulfed me then
i reached to love them all
and i squeezed them and they became
a spring rain and i stood perfectly
still and was a flower*

Nikki Giovanni (1943-)

Second Reading

Now try to create a mental picture of the poem. Attempt to visualize each aspect of the poem circling the most appropriate response as you do so:

Can you visualize:

1. A snowflake falling on to your brow?	1	2	3	4	5
2. A web of snow engulfing you?	1	2	3	4	5
3. Squeezing snow into spring rain?	1	2	3	4	5
4. Turning into a flower?	1	2	3	4	5

Rating scale

The image aroused by the item may be:

Perfectly clear and as vivid as normal vision	<u>1</u>	2	3	4	5
Clear and reasonably vivid	1	<u>2</u>	3	4	5
Moderately clear and vivid	1	2	<u>3</u>	4	5
Vague and dim	1	2	3	<u>4</u>	5
No image at all, you only “know” that	1	2	3	4	<u>5</u>